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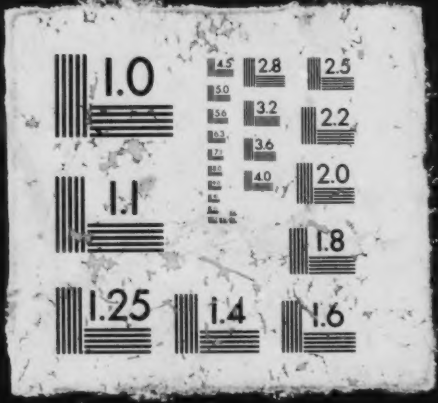
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A REGIONAL RECREATION DEMAND AND BENEFITS MODEL

by

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A REGIONAL RECREATION DEMAND AND BENEFITS MODEL

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ABSTRACT

This report describes a regional recreation demand and benefits model that is used to estimate recreation demand and value (consumers' surplus) of four activities at each of 195 sites in Washington, Oregon, Idaho, and western Montana. The recreation activities considered are camping, fishing, swimming, and boating. The model is a generalization of the single-site travel-cost method of estimating a recreation demand curve to virtually an unlimited number of sites. The major components of the analysis include the theory of recreation benefits, a travel-cost recreation demand curve, and a gravity model of regional recreation travel flows. Existing recreation benefits are estimated for each site in the region and for each activity. Recreation benefits of improved water quality in degraded rivers and streams in the Pacific Northwest are estimated on a county basis for Washington, Oregon, and Idaho. Although water quality is emphasized, the model has the capability of estimating demand and value for new or improved recreation sites at lakes, streams, or reservoirs.

This research documented in this report was started in June 1978 and completed in September 1982.

EXECUTIVE SUMMARY

- A regional recreation demand and benefits model is described and used to estimate recreation demand and value (consumers' surplus) of four activities at each of 195 sites in the Pacific Northwest. The recreation activities considered are camping, fishing, swimming, and boating. The essence of the model is that it generalizes the single-site travel-cost method of estimating a recreation demand curve to virtually an unlimited number of sites. The major components of the analysis include the theory of recreation benefits, a travel-cost recreation demand curve, and a gravity model of regional recreation travel flows. Recreation benefits of improved water quality in degraded rivers and streams in the Pacific Northwest are estimated on a county basis for Washington, Oregon, and Idaho. The model is also illustrated by estimates of existing recreation benefits of selected lakes where water quality is good. Potential and existing recreation benefits are high for sites located near large urban areas and relatively low for rural sites. The model provides quantitative estimates of these benefits. Although water quality is emphasized, the model has the capability of estimating demand and value for new or improved recreation sites at lakes, streams, or reservoirs.

Recreation benefits are defined as willingness to pay, or alternatively as consumers' surplus, and measured as the area under the recreation site demand curve. An improvement in water quality at one site implies an outward shift in the demand curve for that site and a redistribution of demand from substitute sites. The issue of the proper measurement of benefits at an improved site when there are displaced facilities is analyzed with the conventional utility maximization model for consumer behavior. The analysis shows that benefits measured under a single demand curve are net benefits and automatically account for any displaced facilities.

Two major limitations of the travel-cost method of estimating recreation demand are its failure to consider substitute sites and the expense of applying it on a site-by-site basis. A gravity model is used here to overcome each limitation. This model distributes recreation trips to every site in the region on the basis of relative travel costs and relative attractiveness of each site. The output of the gravity model is a trip interchange matrix that is the main input for travel-cost demand curves for each site in the region.

The conventional gravity model is a distribution model, which means that it only estimates the distribution of trips between productions and attractions, which are assumed exogeneous. Because the model does not estimate total demand at each destination, its applicability is limited for most recreation purposes. The gravity model is extended here by estimating it iteratively with an attractions model. As a result, the desirable properties of the gravity model that determine the distribution of trips also influence total demand at each site.

After a demand curve and consumers' surplus are estimated for each of 195 sites in the region, a simulation analysis is used to determine the sensitivity of the results to three computational and specification choices that must be made in the analysis. A semilog specification of a recreation site demand curve is shown to be preferable to a double-log specification. Recreation trip origins may be defined as a system of concentric zones, or as each population centroid. Demand and valuation results are shown to be sensitive to the definition of an origin, although the best definition is not determined.

Quantity demanded at several sites was estimated using travel-cost demand curves and compared to independent estimates of quantity demanded. Errors in these quantity estimates are particularly large when a double-log specification is used, and the errors also depend on the definition of the origin zone.

The regional model is used to estimate recreation demand and consumers' surplus for the four activities at each of 195 sites in the region. Demand and valuation are again estimated assuming that each officially degraded river becomes "fishable and swimmable," which is the goal of the 1977 Clean Water Act. Recreation benefits of improved water quality are estimated quantitatively on a county basis and for each of the four activities.

CHAPTER I

INTRODUCTION

The Clean Water Act of 1977 (U.S. Congress 1977) reaffirms the national goal of eliminating the discharge of pollutants into navigable waters by 1985. This Act defines an interim 1983 goal of protecting fish, shellfish, and wildlife and providing for recreation. These goals--expensive, perhaps impossible to attain in an absolute sense--are becoming less feasible because of the increasing political importance of competing goals. The desire to expand energy supplies and to reduce inflation may conflict with regulations that attempt to achieve a high level of water quality. Furthermore, the benefits to be gained by achieving the Federal goals may not be sufficient in some cases to justify their costs.

The Environmental Protection Agency has begun to incorporate economic factors into its evaluation of water (and air) quality improvement programs. Although the Agency has not completed its approach to defining economic efficiency and to performing marginal analyses, there is a clear movement toward including costs and benefits in the decisionmaking process. However, a major difficulty in attempting to use quantitative cost-benefit estimates is that the Agency has no well-developed and tested procedures for making these estimates. Specifically, the marginal costs of making incremental improvements in water quality in streams and lakes are difficult to estimate. Similarly, the Agency does not have well-developed and tested procedures for obtaining dollar estimates of the benefits of improvements in water quality.

Although several uses of water may be enhanced by quality improvements, recreation benefits appear to be the most extensive.[1] Therefore, this effort will focus on the development of a model to estimate recreation benefits of improved water quality on a regional basis. The model should possess the conventionally desirable properties of reliability and theoretical soundness, but it is also important that the model be operational. Specifically, the model should be able to estimate dollar benefits with a consistent methodology over a large number of sites, quickly and with reasonable cost. One function of the EPA, both at their headquarters in Washington, D.C., and at the regional offices, is to select from a large number of potential sites water-quality improvement projects that are to be funded. Single-site analyses are time consuming and expensive and therefore of limited value. The model presented here combines the gravity model with a travel-cost analysis of recreation behavior to estimate benefits at any site in the Pacific Northwest, which corresponds to EPA Region X, excluding Alaska.

Although the EPA is the intended user of this work, other Federal agencies may find the model appropriate for their recreation planning needs. The Water Resources Council (1979), through its procedures for evaluating costs and benefits, defines the evaluation procedures for water-oriented construction projects that Federal agencies are legally obliged to follow. The Water Resources Council emphasizes three points: (1) recreation benefits should be defined as consumers' surplus; (2) demand should be measured with the travel-cost method or direct willingness-to-pay approach; and if possible, (3) a regional estimator model should be employed. At present, fewer than a handful of models meeting these criteria have been constructed and none has received widespread acceptance. The model presented here uses the travel-cost approach on a regional basis and measures benefits in terms of consumers' surplus. Because the model meets the criteria of the Water Resources Council, it is appropriate for use by those Federal agencies concerned with water-based recreation.

---

[1] According to Freeman (1979a), recreation benefits are more than half of the total potential water quality benefits and more than three times larger than the next most significant benefit.

The construction of new reservoirs and the upgrading of existing reservoirs may encourage additional recreation use, particularly if the appropriate facilities are provided. The model is designed to estimate the change in recreation demand and value resulting from an increment in recreation opportunities. The water-based recreation activities analyzed here include camping, fishing, boating, and swimming. Because these activities are treated separately, in effect four models are constructed. The uniqueness of the model is that demand and benefits can be estimated for any site in the region, which in this study consists of Washington, Oregon, Idaho, and western Montana. Demand and value are estimated separately for 195 recreation centroids and for each of four activities. Because origin and destination centroids can be added or deleted, the model is capable of analyzing demand and value for any site in the Pacific Northwest region.

Chapter II provides the conceptual basis for estimating value and benefits. Recreation benefits are defined as net willingness to pay and measured as consumers' surplus. An improvement in water quality produces an outward shift in the recreation-site demand curve. The increase in benefits is measured as the area between the new and initial demand curves and above the market price, which is typically zero.

A critical step in estimating recreation benefits for a specific site is estimating the recreation demand curve for that site. Chapter IV is a review of the travel-cost method for developing these estimates. The travel-cost method has been used extensively with a good measure of theoretical and empirical support. However, there are several limitations of this approach, for example, the time bias, but the most serious problem for agencies requiring analysis of several sites is the expense and level of effort required to analyze a single site. Visit-rate data by origin are required for each site, and the data from one site usually cannot be applied to other sites. These data are obtained from either household surveys or site attendance estimates, and in either case are not readily available. When identifying projects to be funded, the Agency must select from a large number of candidates. The time and survey expense required to estimate a travel-cost demand curve limits its applicability when it is necessary to select a few sites from among a large number of alternatives. In this study, the travel-cost demand curve approach is generalized to include a large number of sites within a region and can be applied with minimum time and expense. The development and use of regional estimator models is recommended by the Water Resources Council (1979) and is also recommended by Dwyer, Kelly, and Bowes (1977). In addition to economizing on information, such a model can more accurately reflect the influence of substitute sites.

The input data required in a travel-cost demand analysis include travel (mileage) costs and visit rates for each population center that sends visitors to the site being analyzed. Obtaining the visit-rate data is the main time and financial constraint to applying the travel-cost approach over a large number of sites. A regional household recreation survey was undertaken in 1980 covering each of the three Northwestern states. The survey results are used to estimate the number of recreation trips by activity emanating from each population centroid in the region. A gravity model is used to allocate recreation trips from each origin in the region and from external zones to each recreation destination. The model includes 155 population centroids (origins) and has 195 recreation centroids (recreation destinations). The purpose of Chapter III is to develop a regional recreation gravity model. The inputs of the gravity model are also developed and these include a trip production model, an attractiveness model, trip-length frequency distributions and a travel distance or impedance matrix. The output of the gravity model is a trip interchange matrix that, for each destination in the region, is the number of trips from each origin in the region. When those trips are divided by their corresponding population, visit rates are obtained, and they are the critical input in a travel-cost demand curve. By combining household recreation survey results with a gravity model, a model is constructed that has the capability of producing travel-cost demand and valuation estimates for any site in the region.

The main components of the recreation model include the conceptual measure of benefits and value (Chapter II), the gravity model (Chapter III), and the travel-cost demand curve (Chapter IV). Chapter V is an examination of some computation and specification issues involved in calculating a travel-cost demand curve. The functional form of the demand curve and the size of the origin zone are analyzed as possible determinants of travel-cost estimates. In Chapter VI, the operation of the model is discussed and some applications of the model are presented for both lakes and streams. The first application of the model is an estimate of recreation benefits at five selected lakes in the Northwest. The lakes are selected as representative of both urban and rural lakes. Other things being equal, benefits are estimated to be significantly larger in urban than in rural lakes. Recreation benefits which would accrue if the degraded rivers and streams in the Northwest were made fishable and swimmable are estimated on a county basis. The model is also used to estimate demand and benefits resulting from improving water-based recreation areas and from constructing new facilities. Agencies that may have an interest in this work include the Soil Conservation Service, Water and Power Resources Service (formerly the Bureau of Reclamation), Army Corps of Engineers, and others that need to estimate recreation benefits resulting from water-related projects. In a study in progress (Sutherland 1982d), the model is being used to estimate recreation demand and value of the Flathead Lake and existing river system in western Montana.

CHAPTER II

RECREATION BENEFITS AND DISPLACED FACILITIES

1. Introduction

The proper measure of the monetary value of a recreation site has long been of interest to academic researchers and to recreation planners in state and federal agencies. The economic concept of net willingness to pay (or consumer surplus) is now widely accepted as the appropriate measure of benefits. However, a complexity arises when the net willingness to pay for a new or improved site comes at the expense of an existing substitute site. If measured benefits of the new site contain a large component of benefits which have been redistributed from other sites, then these estimated benefits overstate true social benefits.

The issue of how to treat benefits which are redistributed from displaced facilities can be resolved with basic economic principles. The resolution has practical importance to recreation researchers and planners. If benefits can be measured correctly by estimating net willingness to pay for the new or improved site and excluding benefits foregone, then estimating recreation site benefits is feasible. If, however, foregone benefits must explicitly be subtracted from the benefits of a new site, then all relevant substitutes must be identified and their demand curves estimated. Such a task is empirically difficult. The importance of being able to value a recreation site, or more appropriately, the recreation use of a site, requires that we have a concise definition of these benefits.

Some recreation literature is reviewed in Section 2, where it is shown that some researchers are not sure how to treat displaced benefits. Other researchers have constructed elaborate econometric models which explicitly subtract benefits redistributed from substitute sites. The most commonly held view is that benefits can be measured correctly by estimating willingness to pay at the new or improved site and ignoring shifts in the demand for substitutes. A main objective in reviewing these studies is to show the absence of the necessary justification for this position. Indeed, researchers who argue that benefits from displaced facilities can be ignored often derive their support by quoting each other.

One objective of this chapter is to determine the proper measure of benefits of a new or improved recreation site when demand for this site comes at the expense of existing sites. This chapter will serve as the theoretical foundation for the benefit measure used in the regional recreation demand model. In Section 3, benefits are demonstrated to be measured correctly as net willingness to pay for a new or improved site and any displaced benefits can be ignored. The main objective here is to provide theoretical support for this view. The appropriate measure of benefits can be derived from basic economics principles, and it depends on the assumption of whether the prices of other goods, such as substitute sites, remain constant. In Section 4, the development of a new recreation site is assumed to affect the price of other goods. The proper measure of recreation benefits now must include the change in benefits in those markets where prices have changed. This case is clearly the exception, because the price of a recreation site is either zero or fixed, and is therefore insensitive to changes in other prices.

2. An Overview of Benefits in the Recreation Literature

A brief overview of benefits measurement in the recreation literature is presented focusing on two questions: (1) What is the appropriate measure of benefits of a new or improved site when demand for that site comes at the expense of substitute sites? and (2) What is the explicit theoretical justification for the commonly accepted definition of benefits?

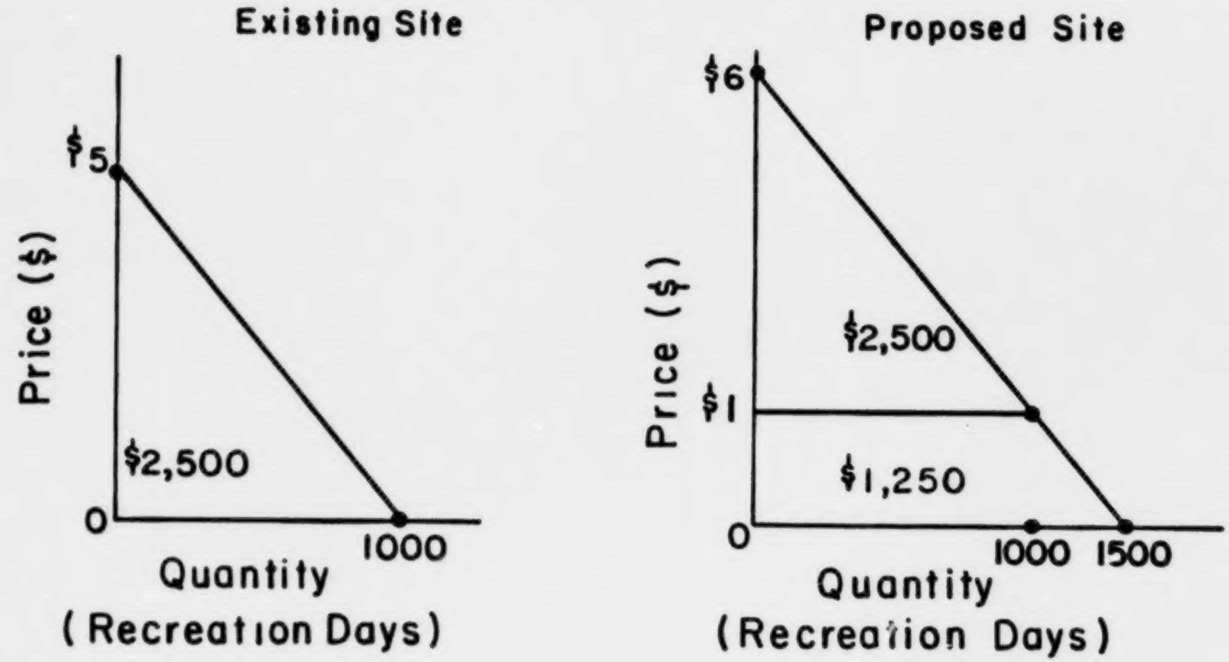
All recreation benefit analyses contain some definition of benefits, but the issue of measuring benefits when there exist close substitutes has only recently been considered. For instance, in the exchange by Stevens (1966, 1967) and Burt (1967) on the fishing benefits of water pollution control, no consideration was given to demand shifts for fishing at substitute sites. Reiling, Gibbs, and Stoevener (1973, p. 3) reveal a clear preference for avoiding this issue by explicity assuming that expanded use of one site does not come at the expense of substitute sites. Some of the more recent literature by Knetsch (1977), Mishan (1976), Freeman (1979a) and Cesario and Knetsch (1976) is reviewed, which explicitly considers measuring benefits at one site when there exist substitute sites. The focus is on how benefits are measured and particularly on how this benefit measure is justified.

A. Knetsch

Knetsch (1977) is concerned with the evaluation of benefits at a proposed site when there is an identical displaced facility requiring a greater travel-cost. To review Knetsch's position, the demand curve for an existing site is depicted in Figure 1. Quantity demanded is 1,000 recreation days and consumers' surplus is $2,500. Assume that a second and identical site is constructed that reduces travel costs by $1 for each population centroid. The demand curve for the proposed site appears on the right hand side of Figure 1.

FIGURE 1

RECREATION DEMAND AND BENEFITS: THE KNETSCH ANALYSIS



The area above $1 and under this demand curve is equal to the area under the demand curve for the existing site. According to Knetsch, the demand curve for the new site slopes downward and to the right from a price less than $1 to P = 0. The demand curve but becomes horizontal at $1 because at a fee of $1 or more all recreationists return to the initial site. The increase in total benefits is $1,250, which is the area under the new (kinked) demand curve. Knetsch concludes that the demand curve for the new facility must reflect existing facilities, but the loss in value of the existing facility can and should be ignored in calculating the net gain of the new facility.

Unfortunately, in Knetsch's analysis measured benefits at the new site do not include a redistribution of willingness to pay from a substitute site because no redistribution occurs. The willingness to pay for the first site is $2,500 before the new site is constructed and, at a price of $1 or more at the new site, it is $2,500 after the new site is constructed. As the price of the new site rises above $1, the willingness to pay for the existing site remains unchanged. Knetsch's analysis is based on a special case where the demand curve for the substitute site doesn't shift. Because there is no decrease in willingness to pay for the substitute site, his analysis provides no support for the position that the decrease in willingness to pay for substitute sites can be neglected when measuring net benefits of a new or improved site.

However, a particularly important econometric implication of Knetsch's analysis is the need to include some measure of substitutes when estimating the site demand function. If the specification of the proposed site excludes the existing site, the continuous demand curve from Q = 1,500 to P = $6 would be estimated. Benefits would be overestimated by $2,500. By correctly specifying the demand for the proposed site, the kinked demand curve would presumably be estimated. Benefits of the proposed site would be correctly estimated at $1,250.

B. Mishan

Mishan (1976), in his authoritative treatise on cost-benefit analysis, addresses the issue of measuring consumers' surplus when increased purchases of one good are at the expense of other goods. Mishan states that if a new good is introduced or the price of a good falls, consumers' surplus should be measured by neglecting changes in consumers' surplus of alternative goods. He says:

> ... I append a note to this chapter containing a simple example in order to reassure the reader that in measuring the consumers' surplus of a new good, or a good the price of which has changed, he should neglect the induced shifts of demand of related goods. (p. 32)

The reduction in the demand for the substitute good shifts the demand schedule to the left producing a decrease in consumers' surplus. According to Mishan, this loss "... is not to be regarded as a loss of consumers' surplus..."; instead, "This reduction in area is simply the consequence of consumers bettering themselves by switching from good y to the new lower priced good x." (p. 34).

When Mishan considers relatively close substitutes he uses a demand schedule for each good, and asserts that the area under the demand schedule for the substitute good can be ignored. He defends his position by example and illustration, but changes the case so that the two goods are perfect substitutes. Because what was two goods is now only one good, an aggregate demand schedule replaces two separate schedules. Specifically, Mishan considers the demand for transportation across a certain water body where a ferry service is being replaced by a bridge. With the ferry service the price is P_0 and consumers' surplus is area P_0ab in Figure 2. After the bridge is constructed, the ferry is discontinued and the price of transportation falls to P_1. According to Mishan, the appropriate measure of the benefits of constructing the bridge is the area under the demand curve and between the new and initial price (P_1P_0bc).

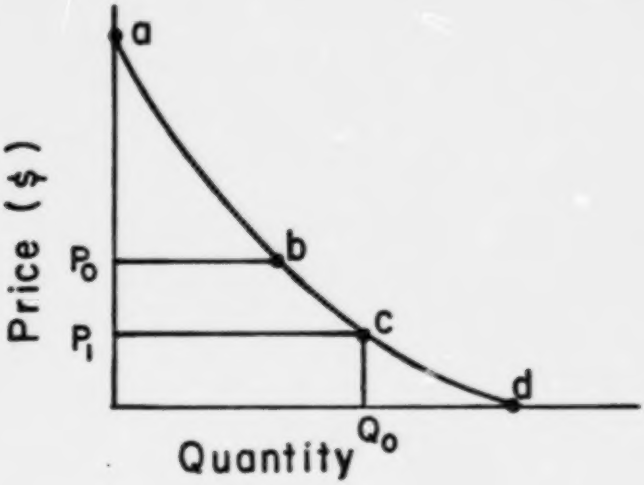
When measuring the increment to benefits, it is possible to think of consumers' surplus foregone as being subtracted from the gross increase. With the ferry service, consumers' surplus was area P_0ab. After the ferry is discontinued, consumers' surplus resulting from the bridge is P_1ac. The increment in consumers' surplus is total surplus after the ferry service (P_1ac) minus consumers' surplus foregone from the bridge (P_0ab); this increment is P_1P_0bc. The reason for subtracting consumers' surplus foregone is that the ferry service is discontinued, and the bridge demand schedule assumes that the ferry is not in operation.

Assuming that the ferry could operate if the price were P_0, the demand schedule for the bridge is dcb as before, but it becomes perfectly elastic at price P_0. The amount of consumers' surplus is the same as above, but it is the area above price P_1 and below the bridge demand schedule. No consumers' surplus is subtracted because no consumers' surplus is foregone.

Mishan's position is that benefits of a new site (in this case a bridge) can be measured by neglecting shifts in the demand for substitutes. However, his justification is an illustration that, in principle, is identical to Knetsch's. By considering the case of perfect substitutes and a single demand curve, Mishan provides no support for the position that the markets for substitutes can be ignored when measuring benefits at a new or improved site. In Mishan's case, like Knetsch's, there is no redistribution in consumers' surplus.

FIGURE 2

CONSUMERS' SURPLUS: THE CASE OF PERFECT SUBSTITUTES



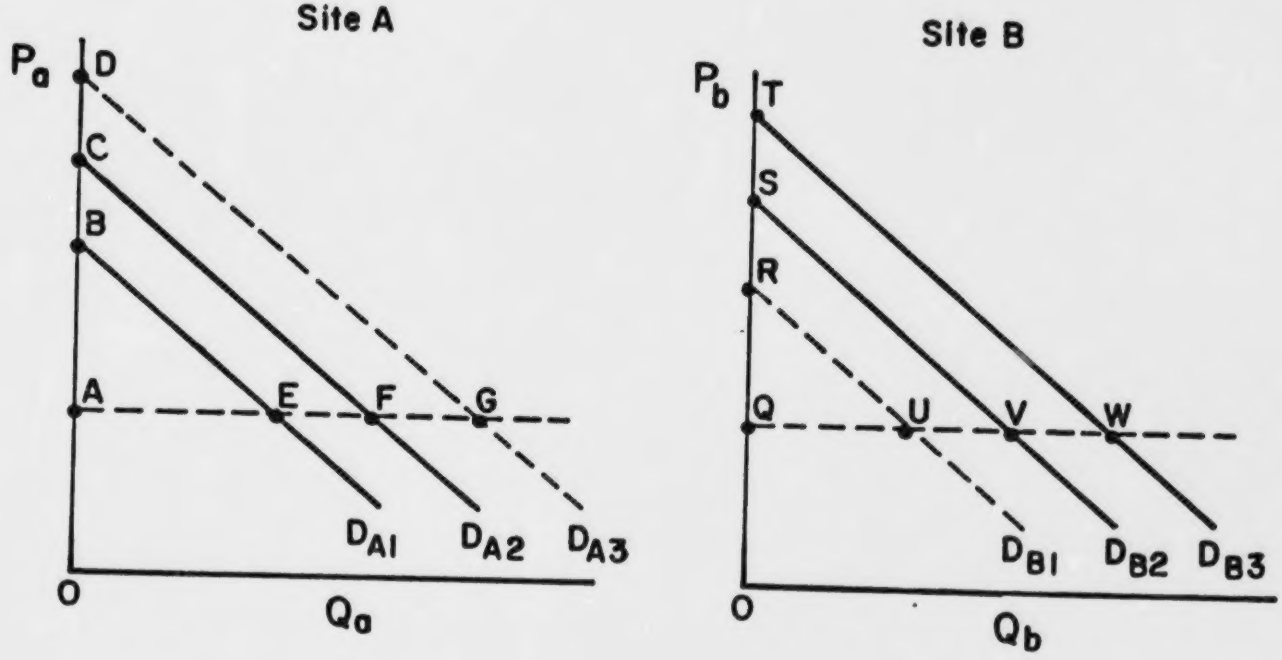
C. Freeman

The analysis of Mishan and Knetsch are special cases and not useful in analyzing the general case where the site demand curve shifts to the right and the demand for substitutes shifts to the left. Freeman (1979b) has explicitly addressed the issue of measuring recreation benefits when the demand curve for substitute sites shifts, so his analysis is reviewed. In Figure 3, the initial demand curves for site A and B are denoted as D_{A1} and D_{B2}. An improvement in water quality at site A shifts the demand curve outward to D_{A3} and the demand for the substitute shifts inward to D_{B1}. Benefits of the improvement are measured as the area between the new and initial demand curves for site A and above the market price (area BDGE). According to Freeman, no consideration should be given to the decrease in willingness to pay for the substitute site, area RSVU. He states:

> In utilizing this measure of benefits, there is no need to take into account changes in recreation use at other sites or savings in travel cost (Knetsch 1977). These are captured by the BECD [BDGE in Figure 3] benefit measure. (p. 199)

FIGURE 3

DEMAND FOR TWO RECREATION SITES



Freeman's conclusion is that benefits can be measured by demand curve shifts at the improved site and demand shifts at substitute sites do not explicitly enter into the benefit calculation. Freeman provides no justification for neglecting the decrease in consumers' surplus at substitute sites, except for his reference to Knetsch. My review of Knetsch's position revealed it to be a special case where there is no decrease in willingness to pay for the substitute site.

D. Support for the Conventional Measure of Benefits

The validity of Freeman's position is not an issue at this point. Rather, the contention here is that the recreation benefits literature (as exemplified by Knetsch, Mishan, and Freeman) does not contain persuasive theoretical justification for the position that displaced benefits should be ignored when calculating net benefits of a new or improved site. Although Mishan, Knetsch, and Freeman reach the same conclusion, they offer no evidence that shifts in the demand for substitutes should be ignored when calculating benefits of a new or improved site. Yet their position seems to be the accepted view of recreation researchers. For instance, Cesario and Knetsch (1976, p. 101) state:

> That is, the value measurement for a new site is measured independently of any diminutive effects on the use of existing sites. Any losses in consumer surplus at existing sites are irrelevant to the calculation (even though it may be informative for planning purposes to calculate the magnitude of these quantities). Such losses merely reflect changed demand characteristics and losses in the value of some fixed assets, and should have no bearing on the benefit calculation for the proposed site which would be judged on its merits alone (McKean 1958; Mishan 1971; Knetsch 1974).

Cesario and Knetsch provide no rigorous justification for this position, relying instead on references such as Mishan and Knetsch. The above review of Knetsch and Mishan argues that they do not support the view that any losses of consumer surplus at existing sites are irrelevant.

Although the sample of recreation benefits literature reviewed here is small, the work is probably the most important in this area. On the basis of this review, two general conclusions are suggested. First, the prevailing view is that benefits of a new or improved site can be measured as the area between the new and initial demand curve and above the market price and, furthermore, that demand shifts for substitute sites need not be considered. Second, the theoretical support for this position has not been made explicit in this literature.

In an analysis of the potential benefits of a new ski site at Mineral King, Cicchetti, Fisher, and Smith (1976) challenge the commonly held view that benefits can be measured by considering only the impacted site.[1] Cicchetti _et al_. specify a simultaneous demand equation model in which the price of each ski site is an argument in each demand curve. They assert that specifying a multisite model allows them to estimate the effects of a change in the price at one site on demand and consumers' surplus at the substitute sites. In an edited version of the Mineral King study, Krutilla and Fisher (1975, p. 198) state that the new Mineral King site would result in a reduction in demand for substitute sites and these effects are captured by measuring the change in consumers' surplus over multiple sites. Bishop and Cicchetti (1973) further explain the benefit measure used in the Mineral King paper:

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[1] Burt and Brewer (1971) used a multiequation model very similar to that of Cicchetti _et_ _al_. (1976).

> In a recent paper Cicchetti, Fisher, and Smith (1972) simultaneously estimate the demand for various skiing sites in California. The location of other sites and therefore their relative prices are taken into account explicitly by using a generalized least squares regression approach. The benefits of new sites at various locations can be determined by simultaneously estimating the change in consumer surplus for the alternative sites. (p. 111)

The estimate of consumers' surplus in the Mineral King study explicitly reflects the reduction in willingness to pay for substitutes. This position is in marked contrast to that taken in the studies discussed above and implies the need to define the theoretical underpinnings of the prevailing view.

3. The Theoretical Underpinning for the Conventional Measure of Recreation Benefits

The above review of the definition of recreation benefits suggests some ambiguity on the issue and the absence of agreement on theoretical support for any particular definition. Benefits are now demonstrated to be properly measured by considering only the demand curve for the affected site. Furthermore, this demonstration follows from an application of economic principles.

The following analysis may assume an environmental improvement at a recreation site (hence a demand curve shift), a decrease in the price of a site, or the introduction of a new site. On grounds of expositional convenience, consider the net benefits of introducing a new recreation site. Panel B in Figure 4 depicts an ordinary demand curve (ODC) and a Hicks compensated demand curve (HCDC), where OD depicts the quantity of the new good demanded at price P_1.[2] Net benefits of the new good can be measured as the area under the

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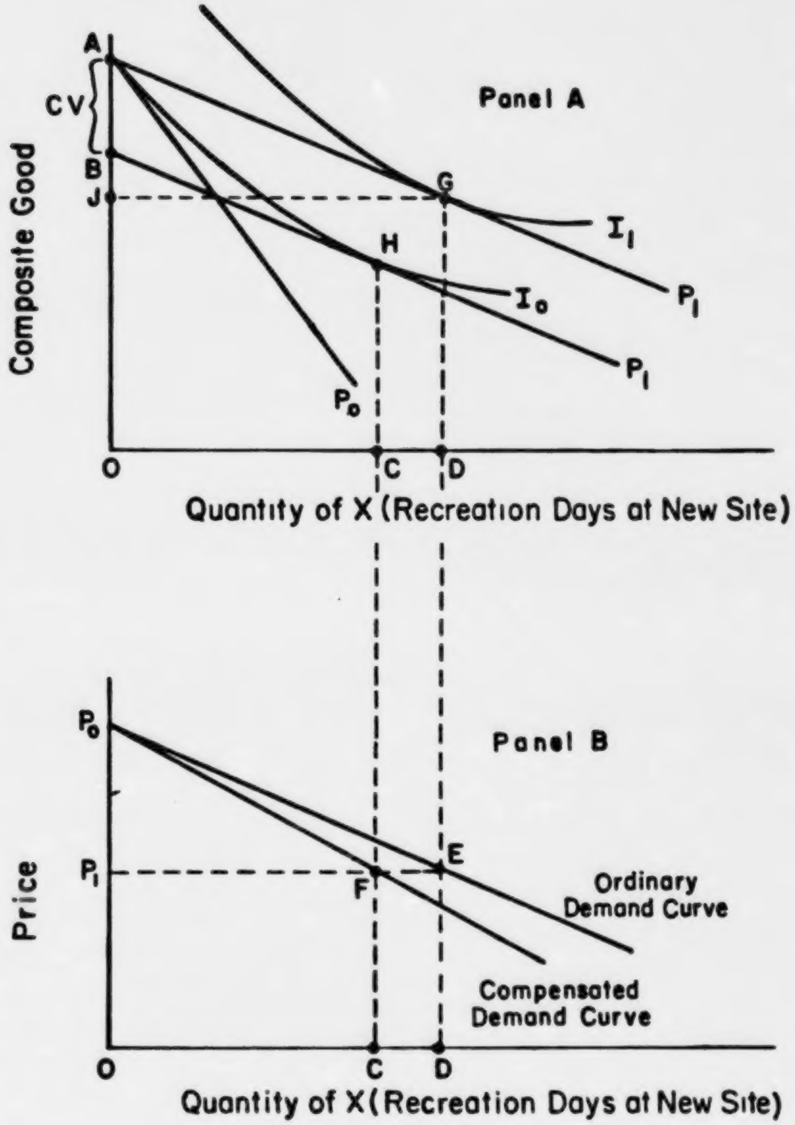
[2] A decrease in the price of a good increases the quantity demanded because people substitute this good for other goods and because the lower price effectively increases real income. The ordinary demand curve reflects both this substitution and income effect. The compensated demand curve reflects only the substitution effect and presumes that real income is unchanged.

FIGURE 4

CONSUMERS' SURPLUS USING ORDINARY AND COMPENSATED DEMAND CURVES


Panel A
A
CV
B
J
G
H
I₁
I₀
P₁
P₁
P₀
Composite Good
O
C
D
Quantity of X (Recreation Days at New Site)
Panel B
P₀
P₁
E
F
Ordinary Demand Curve
Compensated Demand Curve
Price
O
C
D
Quantity of X (Recreation Days at New Site)

compensated demand curve and above the market price, area P_1P_0F. This area reflects the change in consumers' surplus caused by introducing the new good and is defined as the willingness to pay for the new good over the above actual payment. On grounds of empirical necessity and the work by Willig (1976), consumers' surplus, as measured under the ordinary demand curve, is generally considered an acceptable approximation to the area under the compensated demand curve. According to Knetsch, Freeman, Mishan, and Cesario and Knetsch, benefits of a new site are measured as the area under the compensated demand curve, or approximately as the area under the ordinary demand curve. At issue is whether this area correctly measures the benefits of a new site and what consideration if any should be given to benefit from displaced facilities.

This question is answered by deriving a demand curve for a new recreation site using indifference curves and price lines. Assume that a utility-maximizing consumer allocates all his income between good X (the new recreation opportunity) and a composite of all other goods, which is termed Hicksian money. Before the recreation opportunity was provided, the consumer purchased only the composite good and did not consume good X. As depicted in Panel A of Figure 4,[3] this initial allocation is defined by point A, which is the point of tangency between price line P_0 and indifference curve I_0. After the recreation opportunity is provided, P_1 becomes the price of recreating relative to the price index of the composite good and the consumer maximizes utility by moving from point A to point G. The change in welfare, as measured by the compensating variation, is AB after it has been converted to dollar terms by multiplying by the price index of the composite good. A well-known proposition in welfare economics, and critical point here, is that this measure of consumer surplus in

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[3] The diagram in Figure 4 was presented by Currie, Murphy, and Schmitz (1971).

Panel A corresponds to consumer surplus as measured under the compensated demand curve in Panel B. We can now focus on the welfare gain AB in Panel A.

Recreation use at the new site (good X) comes partially at the expense of substitutes, which in this case is the composite good. As a result of the new recreation opportunity, use at the site becomes OD (Panel A) and demand for the substitute decreases by AJ. Hence the improvement in welfare, which is measured by the movement from indifference curve I_0 to I_1, clearly reflects a reduction in demand for the substitute composite good. The demand curve and consumer surplus in Panel B do not imply how foregone benefits should be treated. However, the derivation of this demand curve and the corresponding measure of consumer surplus (AB in Panel A) show clearly that measured consumer surplus is a net increment to benefits.

The above analysis supports the conventional measurement of benefits, subject, however, to a stringent assumption. As seen in Figure 4, Panel A, the composite good is an aggregation or weighted sum of all other goods, where the weights are the prices of these goods. As stated originally by Hicks (1939, p. 33), if the relative prices of a group of commodities are given and unchanged, these commodities can be lumped together and treated as a composite good. Hicks' theorem of group commodities is being used to justify defining the decrease in relative price of good X. Specifically, the above conclusion assumes that lowering the price of a new good does not affect the relative prices of other goods.[4] If the introduction of a new site affects relative prices of other goods, the composite good theorem is not applicable. At issue, then, is determining the proper measure of consumer surplus under conditions of multiple-price changes.

4. Consumer Surplus with Multiple-Price Changes

The view that recreation benefits can be measured by considering only the market for the single affected site is correct if we assume an ordinary Marshallian partial equilibrium demand curve.[5] In the Marshallian demand curve, prices of all other goods are fixed, and therefore Hicks' theorem of composite goods is applicable.[6] In this section we consider the measure of recreation benefits when a new or improved site affects prices in more than one market.

Although the recreation literature gives little attention to this issue, it has been treated at length in the welfare theory literature by Harberger (1971) and Mohring (1971) among others. Borrowing an illustration from Mohring, assume two goods, margarine and butter, whose demand functions can be written as

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[4] According to the Cicchetti et al. analysis, for each individual, relative prices of existing sites are invariant to the construction of a new site. However, the price of the new site relative to that of existing sites differs according to the origin of the individual. The latter point does not nullify the use of the composite good theorem, which seems appropriate in the Cicchetti et al. study and in the Burt and Brewer study. In these studies, there was a decrease in the price of the new site that produced a shift in the demand for substitute sites, but relative prices of these substitute sites remains constant. Burt and Brewer and Cicchetti et al. used a quadratic benefit estimation equation that is a generalized approach for integrating a system of equations, in this case, when prices change at one or more sites. Because only one price changes (the new site), the simpler technique of integrating that demand equation would have been appropriate.

[5] The Marshallian demand curve is a sufficient but not necessary condition to consider only the affected site. If all other prices change proportionately, the composite good theorem still holds.

[6] Freeman (1979b, p. 35) and Mishan (1976, p. 32) recognize the necessity of invoking Hicks' composite good theorem when analyzing benefits in a single market.

$$Q_m = f_1(P_m, P_b, Y)$$
$$Q_b = f_2(P_m, P_b, Y) \quad ,$$

where the price of margarine (P_m) and the price of butter (P_b) enter into each demand equation along with income (Y). Initial equilibrium in the margarine and butter markets is defined in Figure 5 by points A and C, respectively. The margarine market is analogous to our proposed site, except that Mohring's initial change is a reduction in price. The price of margarine falls from P'_m to P''_m, which produces a decrease in the demand for butter from D_b to D'_b. If the price of butter remains constant at P'_b, consumer surplus is measured as the area under the margarine demand schedule between the new and initial price.

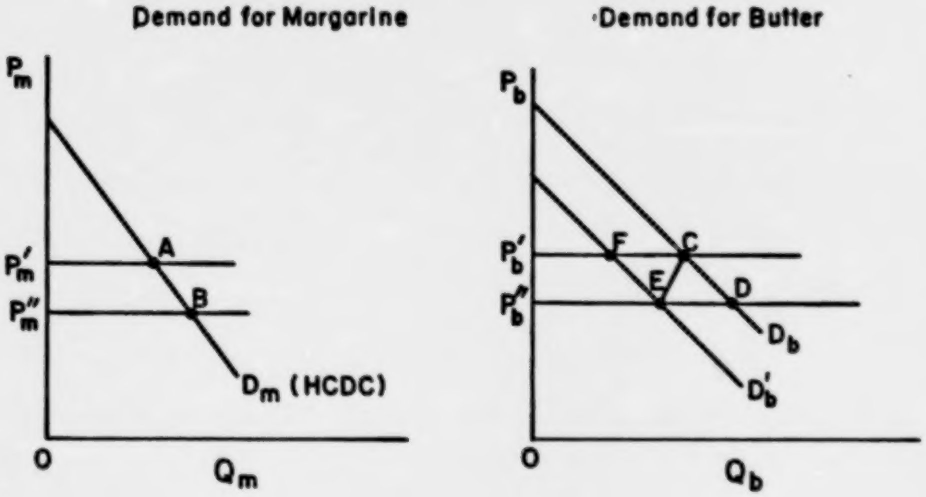
Mohring emphasizes that even though the butter demand schedule shifts, this fact need not be considered when measuring the increase in benefits resulting from lower priced margarine. This point corresponds to our conclusion in the previous section that benefits are correctly measured under the demand curve for the affected recreation site, and displaced facilities can be ignored.

Suppose the illustration is changed so that a decrease in the price of margarine decreases the demand for butter as before, but now the price of butter falls from P'_b to P''_b. This price decrease in butter increases the net willingness to pay for butter and the increment in consumer surplus must be added to the increase in consumer surplus for margarine to obtain the appropriate measure of welfare change. This point is well recognized in the welfare economics literature and can be generalized to state that the change in consumer surplus resulting from price changes in several markets is the sum of the increment of consumer surplus in each market (Harberger 1971).

Mohring emphasizes the ambiguity of measuring the change in consumer surplus in the butter market, and he notes that three measures have been proposed. Using the initial butter demand curve, consumer surplus is $P''_bP'_bCD$,

FIGURE 5

MEASURING BENEFITS WITH MULTIPLE-PRICE CHANGES


Demand for Margarine

Demand for Butter

but this measure is $P''_bP'_bFE$ if the new demand schedule is used. If we move from the initial to new demand schedule, the change in consumers' surplus is $P'_bCEP''_b$. Because a rationale can be presented for each of these definitions, the measurement of consumer surplus is, in general, sensitive to the definition chosen. This point is recognized in the welfare theory literature and has led Silberberg (1972) to conclude that the appropriate change in utility or welfare cannot be defined unambiguously. Hotelling (1938) noted this indeterminancy in the measure of benefits and also the condition under which consumer surplus could be measured unambiguously. This condition is known as the integrability condition, and means that the demand curves have identical cross partial derivatives with respect to prices. The integrability condition for the margarine and butter demand curves is

$$\frac{\partial Q_b}{\partial P_m} = \frac{\partial Q_m}{\partial P_b} \quad ,$$

which says that the change in the quantity of butter (Q_b) demanded resulting from a change in the price of margarine equals the change in the quantity of margarine (Q_m) demanded resulting from a change in the price of butter. As noted by Mohring (p. 356), this condition holds if the demand curves are Hicks income-compensated or if the income elasticity of demand for both goods is zero. Burt and Brewer (1971) and Cicchetti *et al*. (1976) recognized this requirement, and therefore specified their demand equations as linear and symmetrical.

These conclusions can be restated in terms of our main concern of valuing a recreation site that has a substitute site. Let the price of recreating be defined as the entrance fee or as travel costs. If a decrease in the price of a recreation site (or the construction of a new site) affects the demand for substitutes or complements, but leaves their prices (entrance fees or travel costs) unchanged, benefits are estimated properly as the area under the site demand curve and between the initial and new price. No explicit consideration should be given to the decrease in willingness to pay for the substitute site. Alternatively, if the decrease in the price of a site causes a change in relative prices of other goods, such as a substitute site, the increment (decrement) in consumer surplus in the substitute site resulting from the price change must be added (subtracted) to that of the first site to obtain the total change in consumer surplus.

A peculiar feature of outdoor recreation is that the price of recreating, as measured by entrance fees, is generally zero. Where entrance fees are charged, for example campgrounds, these prices are insensitive to the introduction or improvement in substitute sites. Where travel costs are used as a proxy for price, the travel cost to substitute sites is invariant to a demand shift at the site being analyzed. Therefore, for most all practical applications in recreation, including the travel-cost approach that is used here, benefits of a new or improved site can be measured correctly as consumer surplus at the new or improved site.

5. Conclusions

This chapter addresses the issue of the proper measure of benefits at a new recreation site when demand for that site comes partially at the expense of substitute sites. The literature reviewed indicates that some researchers have avoided the issue; others have explicitly subtracted benefits foregone. The prevalent view is that benefits can be measured by considering only the new site demand curve. The limitation with this view is the absence of any theoretical justification. As shown here, benefits are measured correctly by considering only the demand curve for the new site, but this demand curve must be correctly specified to consider existing sites. Use of the conventional microeconomic model of consumer behavior shows that recreation benefits, measured as willingness to pay for the new site, automatically net out benefits foregone from substitute sites. In the special case where the introduction of a new site causes prices of other sites or goods to change, the increment in benefits is the net sum of consumers' surplus in these affected markets.

CHAPTER III

ESTIMATING RECREATION TRIPS WITH A GRAVITY MODEL

In Chapter II it was established that recreation benefits can be defined as the area under the recreation demand curve above the market price. Chapter IV contains a discussion of the travel-cost approach to estimating a recreation demand curve. This chapter presents the methodology used to obtain the input data of the travel-cost demand curves. A 1980 regional household recreation survey is used to estimate the number of recreation trips by activity from each origin in the region. An attractiveness model is used to obtain preliminary estimates of the attractions of each site in the region. The distribution of trips between each origin and destination is estimated by using a gravity model. The gravity model and attractiveness model are then integrated, and quantity demanded at each site is estimated with the revised attractiveness model. The output of the gravity model is the number of visitor days received by each site in the region by activity and emanating from each origin in the region. These outputs are the basic input required to calculate a travel-cost demand schedule for each recreation site in the region.

This analysis of recreation behavior differs from existing studies by virtue of magnitude, with 195 recreation centroids defined over three and one-half states. This scale is considerably larger than those in the regional models of Burt and Brewer (1971), Cichetti, Fisher, and Smith (1976), Cesario and Knetsch (1976) and Knetsch, Brown, and Hansen (1976). The primary advantage of this size model is that any site within the region can be analyzed. Also, the influence of all potential substitute sites is most likely to be reflected in a larger model. The ability to analyze a large number of sites results from the use of household surveys to estimate recreation trips by origin and a gravity model to estimate the distribution of these trips.

Most recreation analyses focus on one activity or treat recreation as a composite homogeneous good, for example, Stevens' (1966) estimate of the fishing benefits resulting from improved water quality. In contrast, this analysis considers four activities: camping, fishing, boating, and swimming. A focus on one activity may be inadequate when several activities respond to water-quality improvement. These four activities are not homogeneous; they differ in their response to site characteristics such as water quality, average travel distance and length of stay, and value per activity day. Furthermore, the relative composition of these activities varies widely across recreation sites. For these reasons, the above four activities are analyzed separately.

A fundamental difference between this study and other regional travel-cost studies is the method of obtaining input data. In the regional models of Cesario (1973, 1974, 1975), Cesario and Knetsch (1976), Cheung (1972), and Knetsch, Brown, and Hansen (1976), origin-destination data were obtained from site attendance records or on-site surveys. In this study, origin-destination allocations are estimated from a gravity model that uses origin data from household recreation surveys. The costs and benefits of this approach relative to that of using site-specific attendance data merit brief comment.

The initial cost of a regional household recreation survey and regional model is of course substantial, but once the survey is taken and model constructed, the marginal cost of analyzing additional sites is less than that of most single-site analyses. The cost of using existing attendance records is low, but in the Northwest, these data are deficient in both quantity and quality. Several agencies, such as the Corps of Engineers, Water and Power Resources Service, U.S. Forest Service, and state parks departments have total attendance data, but not by origin. Agencies may define attendance in terms of visits, visitor days, recreation days or activity days, and the definitions of these terms tend to vary between agencies. The on-site survey approach is less expensive when the number of sites is small, but more expensive when the number of sites is large. The number of sites at which the costs of the household survey and site survey approach are equal cannot be defined *a priori*.

The household survey approach coupled with the model presented here offers significant advantages over the on-site survey approach. The present model can estimate demand and consumers' surplus for a proposed site at any location in the region. The on-site survey approach obviously cannot obtain attendance data for a proposed site; so the demand function for the proposed site must be estimated by assuming that the site is similar to an existing site. The demand for a site depends on site characteristics, distance to population centers, size of the population centers, and alternative sites available to each population origin. A model based on these variables can be used to estimate input data for the demand curve of a proposed site; but the model would, at best, produce reliable estimates of total quantity demanded. However, the distribution of these trips by origin would be estimated with large errors unless substitute recreation opportunities were accurately modeled for each origin. Existing regional models do not have this capability, and consequently are limited in terms of estimating demand curves for proposed sites. The model presented here can estimate total quantity demanded for a proposed site and the distribution of this demand by origin. In addition to being able to estimate demand and benefits for any site in the region, the estimates should be more reliable than those based on "similar sites" and site-attendance data.

The travel-cost approach is not applicable when most users come from one origin because travel distances and, hence travel costs, will not possess significant statistical variability. The average distance traveled for fishing, swimming, and boating is about 40 miles, and a large number of recreation sites are located near urban areas. If the site survey defines origin as county or city, the data will be inadequate for a large number of sites. The methodology used here permits dividing urban areas into several population centroids. In this way, the travel cost is measured accurately for a large number of recreators, and travel costs will vary over these users.

As a brief overview, the model consists of four integrated components: a trip production model, an attractiveness model, a trip distribution (gravity) model, and a demand and valuation model. The trip production model is used to estimate the number of recreation days by activity that emanate from each population centroid in Washington, Oregon, Idaho, and western Montana. The attractiveness model is used to estimate the attractiveness, or total quantity demanded, of each recreation centroid in the region. Recreation days produced and attracted enter a gravity model where they affect the distribution of recreational travel. A gravity model estimates a trip interchange matrix that, for each recreation centroid, is the number of activity days received from each origin. These outputs are used to estimate a travel-cost demand curve for each recreation destination and for each of the four activities considered. Recreation value is measured as the area under the demand curve and above the market price, which in this study is presumed to be zero. An improvement in water quality coupled with an increase in facilities produces an outward shift in the demand curve, and the area between the initial and new curve represents the benefits of improved water quality.

1. Gravity Model Overview

The gravity model as applied to travel behavior is a trip distribution model that is used to estimate trip interchanges between all pairs of origins and destinations. Normally, the number of trips produced and received by each zone are exogenous variables. The endogenous variable is the allocation of these productions. The basic premise of the model is that the number of trips produced by origin i and attracted to destination j is directly proportional to (1) the total number of trips produced in i, (2) attracted to j, and (3) inversely proportional to a function of spatial separation between the zones.

The gravity model is ideally suited to estimate the distribution of recreation travel. However, the most stringent limitation of the model, for purposes of recreation analysis, is the requirement that attractions are exogenous. According to this assumption, the quantity of recreation use demanded at each site is known, and the gravity model solves for the allocation of this demand by origin. Previous versions of this study, including Sutherland (1982c), are subject to this limitation. The gravity model is developed in this chapter first, along traditional lines, and using exogenous attractions. In the latter part of this chapter, the gravity model is extended to simultaneously estimate attractions. This extension is shown to result in a substantial improvement, both theoretically and empirically, in the regional recreation demand model.

The gravity model has a long history of successful applications in economics and in transportation analysis, but has also been used to analyze recreation travel. The primary use of the gravity model in economics has been to analyze regional trade flows. Anderson (1979, p. 106) conjectures that this model is the most successful empirical trade device to evolve in the last 25 years. Regional economics books, such as Isard's (1960), typically contain a discussion of this model. However, the most frequent application of the gravity model is to estimate both interurban and intraurban travel flows. The gravity model appears to have had a long and successful history as a tool for analyzing travel flows. The prominent position of this model is confirmed by the attention given it in the transportion engineering texts, such as those by Hutchinson (1974), Dickey (1975), and Stopher and Meyburg (1975).

The gravity model owes its theoretical foundation to Newton's Law of Gravitational Force, which stated loosely, is that the gravitational force between two bodies is directly proportional to the product of their masses and inversely proportional to the square of the distance between them. A frequent criticism of the model as applied in economics is that the theoretical foundations are in physics and not in the principles of social behavior. This criticism has been answered by some recent work that establishes a theoretical foundation for the gravity model. For example, Anderson (1979) provides a theoretical explanation of the model as applied to commodities. Niedercorn and Bechdolt (1969) derive a gravity model from consumer theory by using a logarithmic and power utility function.

Despite theoretical support and extensive empirical success in predicting urban travel, the gravity model has been used infrequently in analyzing recreation travel and with limited success. Ellis and Van Doren (1966) found the gravity model predictions of camping in Michigan to be less reliable than those from a systems theory model. Freund and Wilson (1974) obtained some rather large discrepancies between gravity model predictions of recreation behavior in Texas and observed behavior.

Several specifications of the model have been put forth; the specification used here is one which is used widely in transportation analysis and was developed by the Bureau of Public Roads (1965). The equation is

(III.1) $$T_{ij} = P_i \frac{A_j F_{ij}}{\sum_j A_j F_{ij}} ,$$

and the constraints are

(III.2) $$\sum_j T_{ij} = P_i \text{ and}$$

(III.3) $$\sum_i T_{ij} = A_j$$

where i refers to origin and j to destination. The symbols in (III.1) are defined as

T_{ij} = number of activity days produced at i and attracted to j,

P_i = number of activity days produced at i,

A_j = number of activity days attracted to the jth recreation centroid, and

F_{ij} = a calibration term for interchange ij, which reflects the effect of distance.

Equation (III.2) states that the estimated trip interchange matrix (T_{ij}) must imply that the total number of trips from origin i ($\sum_j T_{ij}$) is equal to the exogenous number of trips produced. In the calibration procedure used here and elsewhere, this constraint is satisfied automatically. According to Eq. (III.3), the estimated trip distribution matrix, which estimates the number of trips terminating at each site, must also be consistent with exogenously estimated attractions.

The gravity model, as generally used, is a distribution model; it takes a given number of recreation activity days emanating from population centroids and distributes these days according to the relative attractiveness and spatial impedance between centroids. In the special case where site-attendance data and trip-production data are available, the gravity model is well suited to estimate allocation of these trips. If site-attendance data are unavailable, they must be estimated by a demand model. Ideally, a demand model would include travel costs to all substitute sites and the relative attractiveness of all substitute sites. Such a demand model would be quite similar to the gravity model. In this study, the gravity model is extended to include endogenous attractions; hence, it becomes a demand and distribution model.

As noted by Ewing (1980), Eq. (III.1) has two important properties. Adding destinations to the system or increasing the attractiveness of the existing destinations will increase the number of trips to that destination, but at the expense of alternative destinations. That is, the total number of trips is exogenous. Second, the model allocates trips by considering the substitutability between recreation centroids, a property particularly important for recreation analysis. The proportion of trips emanating from i with destination j is a function of the attractiveness and spatial impedance of destination j relative to that of alternative recreation centroids in the system. As reflected in the denominator of Eq. (III.1), all sites in the region are considered as potential substitutes being analyzed. This property, plus the definition of substitutes in terms of both travel distance and attractiveness, make the gravity model appealing for a regional recreation analysis. Because the quantity of recreation demanded at each site depends on the same variables that are in the gravity model, it is important to incorporate this interdependence in the overall model.

When applied to transportation problems, the dependent variable is trips; however, the variable of interest in recreation studies is recreation days or activity days. In this study, the terms will be used synonymously, and a distinction will be made only for trips of more than one day. Origins and destinations are often defined as zones or centroids. The term population centroid is used to define the origin zone, and recreation centroid to define recreation zone. In each case, a centroid is a point but is used to represent origins and destinations of the neighboring area.

The rationale for using a gravity model is that the estimated trip interchange matrix (T_{ij}) serves as an input in estimating a large number of trāvel-cost demand schedules. Each column vector in T_{ij} estimates the number of recreation activity occasions produced at origin i with a specific recreation destination. In this study j = 1,2, ..., 195 so 195 demand curves can be estimated for each of the four activities considered. Because destinations can be added to the analysis, the model potentially can estimate a demand curve and recreation value for each activity and for any site in the region. The construction of the gravity model input data is explained in Section 2.

2. Gravity Model Input Variables

The three gravity model input variables are developed in this section. The spatial impedance variable (F_{ij}) is discussed first,. followed by the trip production model (P_i) and the attractiveness model (A_j).

A. Fraction Factors (F_{ij})

A necessary input to construct the F_{ij} terms is the impedance matrix (I_{ij}), which contains the minimum driving distance from each population centroid (internal and external to the region) to each recreation centroid in the three and one-half state region. This matrix was estimated by first defining the population and recreation centroids of each county, and where appropriate, multirecreation or multipopulation centroids were used per county. There are a total of 129 counties in Washington, Oregon, Idaho, and western Montana, but there are 141 internal population centroids and 195 recreation centroids. In this model the remainder of the United States and Canada is divided into 14 external zones, so there are a total of 155 population (origin) centroids. Table A.1 in Appendix A lists the population centroids by name and county and gives the corresponding population. Table A.2 lists the recreation centroids by name and the corresponding county. After each centroid was defined and located on a highway map, a network was constructed to show the distance between intersections along major roads. Possible routes from each population centroid to each recreation centroid were thereby identified. A computer program was used to solve for the minimum driving distance between each population and recreation centroid. The resulting travel distances constitute a 155-by-195 impedance matrix. Each column vector in this matrix denotes the minimum one-way mileage from each population centroid to a specific recreation centroid. The impedance matrix is an input in the gravity model, and the column vectors in the matrix will also be used as inputs in the travel-cost demand curves.

The F_{ij} variable in (III.1) reflects the influence of travel distance (or time) on the propensity to travel. This variable is estimated as the dependent variable in a trip-length, relative frequency distribution, which is also termed a decay curve.

Our 1980 regional household survey included a question on the one-way travel distance in miles for each recreation trip. Because the sample size exceeds 3,000 and several persons in each household may have taken numerous trips, only a subsample of the sample results is used to estimate the decay curves. We sampled every fifteenth questionnaire and recorded the number of activity days by type and the corresponding one-way miles traveled.

The widespread use of gravity models has resulted in serious study of the shape of decay curves and ways to estimate them. One approach is to use the power function $F_{ij} = \beta_0 D_{ij}^{\beta_1}$ where F_{ij} is the proportion of trips from i to j and D_{ij} is the corresponding distance. Another option is the exponential function $F_{ij} = \beta_0 e^{-\beta_1 D_{ij}}$. Either of these functions may be adequate, but quite often decay curves are humped and highly skewed to the right. For instance, people are more likely to travel 40 to 50 miles to camp than to travel 5 to 10 miles, particularly if they live near city center in a large city.

The preferred decay curve model of most researchers is a gamma distribution, which is a combination of the exponential and power functions:

$$F_{ij} = \beta_0 D_{ij}^{\beta_1} e^{-\beta_2 D_{ij}} \quad . \tag{III.4}$$

The β_1 coefficient may be positive and thereby allow for a peak in the decay curve. This specification is used to estimate a decay curve for each of the four activities being considered. The results are presented in Table 1.

The coefficients for the exponent are not negative as expected, nor are they statistically significant. The R^2 values indicate that each of the equations has rather low explanatory power. These apparently discouraging results are easy to explain. The raw data do not depict the above relationship for three of the four activities. Consequently, one of the reasons for using the gamma distribution is not applicable to those data. Also, respondents tended to round off their distance traveled on long trips to the nearest 50 miles. For example, respondents indicated a total of 522 recreation days at 300 miles and no recreation days at 310 or 290 miles. The tendency for long trips to consist of "spikes" (and zeros) means that the regression estimate is too high in the tails. The consequence of using the gamma estimates in Table 1 in the gravity model would be to allocate far too many people on long trips.

The data error caused by respondents' rounding distances to the nearest 50 miles implies that any specification estimated with ordinary least squares would not yield a good fit. Consequently, the decay curves are estimated here using

TABLE 1

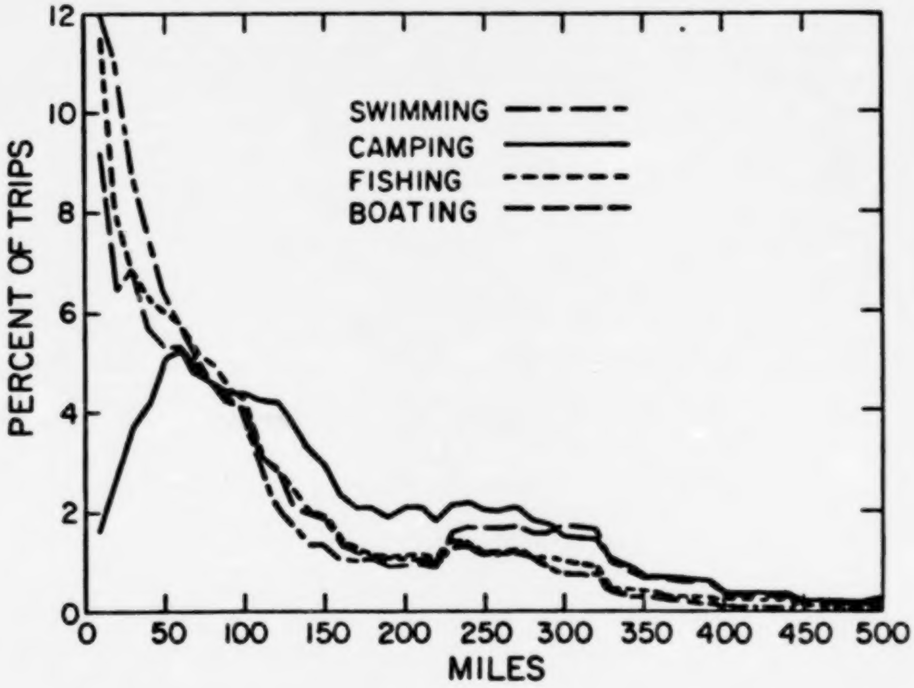
REGRESSION ESTIMATES OF A GAMMA SPECIFICATION OF THE DECAY CURVE

Activity	Intercept	Power	Exponent	R^2
Swimming	6.73 (8.22)	-1.30 (-2.58)	0.03 (0.99)	0.34
Camping	5.76 (7.46)	-0.051 (-1.05)	0.01 (0.28)	0.10
Fishing	6.77 (7.85)	-1.18 (-2.20)	0.02 (0.49)	0.34
Boating	5.98 (6.78)	-1.09 (-2.03)	0.03 (0.71)	0.25

Note: The numbers in parentheses are t values. R^2 is the coefficient of determination.

FIGURE 6

ESTIMATED DECAY CURVES USING EXPONENTIAL SMOOTHING



exponential smoothing. In this procedure, the estimated proportion of people traveling any distance is equal to the sum of the proportion of people traveling the previous x distances divided by x. After experimenting with x = 5, 10, and 15, it was decided to smooth over the previous 10 distance groups, where distance is also measured in 10-mile increments. The estimated decay curves using exponential smoothing are depicted in Figure 6. The trip-length frequency distributions in Figure 6 show that recreationists who swim, fish, and boat strongly prefer to travel short distances. In contrast, the camping decay curve is peaked, with most camping trips occurring between 50 and 100 miles.

The main use of these decay curves is to transform impedance values into the F_{ij} matrices. By substituting each impedance value into the four decay curves, an F_{ij} matrix is constructed for each activity. This matrix is one input in the gravity model, Eq. (III.1). The estimates in an F_{ij} matrix can be interpreted as the probability that a recreator residing in origin i will travel the distance from i to destination j.

B. Trip Production Model (P_i)

A household recreation survey was conducted in the fall of 1980 to obtain data to estimate recreation trips produced by origin by type of trip. A telephone survey was undertaken by the Survey Research Center at Oregon State University, specifically for use in this model. Appendix B contains a copy of the questionnaire. A statistical methodology used to construct trip-production estimates was developed by Carter (1981) as part of her dissertation. In the methodology she developed, the sampling unit is the county, not the individual or household, as is typical in most studies. Forty counties (out of 119 counties in Washington, Oregon, and Idaho) were sampled, with the average size of 75 households per county. A recreation trip production model, based on the

40 sampled counties, was then used to extrapolate to the remaining counties. Because trip productions are estimated to be negative for few counties, the overall reliability of the estimates cannot be confirmed. An alternative trip production model is developed here, estimated with the Oregon State survey data.

In most recreation participation analyses, the sampling unit is the individual, and a specific activity is being considered. Because a high proportion of individuals generally do not participate in the specific activity, there is a corresponding large number of zeroes. The assumption of normality is therefore likely to be violated. Most resarchers have employed a two-step procedure. First, a dichotomous dependent variable is used to denote whether the person participated and, for those persons who participated, the number of days participating is the dependent variable in the second model. The independent variables in these models are demographic, such as age, sex, and income, and some measure of the supply of recreation opportunities.

A common and serious problem shared by these models is their very low overall explanatory power. For instance, Davidson, Adams, and Seneca (1966) obtained R^2 values of 0.28, 0.11, and 0.11 for the probability of participating in swimming, fishing, and boating, respectively. Hay and McConnell (1979) obtain R^2 of 0.02 and 0.03 for participating in nonconsumptive recreation such as wildlife photography. Cicchetti (1973) reports the goodness of fit for several recreation participation equations (p. 69, 73, 75), and each is below 0.18, and several are less than 0.10. In previous versions of this model, I used the conventional two-step procedure and obtained unsatisfactory results.

In addition to the statistical difficulty of a large number of zero responses, there may be conceptual difficulties with focusing on individuals and single activities. Where the family unit recreates together, individuals do not act independently. Also, household members may participate in several activities during one recreation trip; hence activities, like household members, may not be separate and independent.

An implicit assumption in previous participation analyses is that participation per capita varies across regions. However, this assumption has apparently been untested in the literature. One estimator of per capita participation is the sample mean number of recreation days per person. Considering the low explanatory power of most recreation participation models, this estimator may be quite reasonable. As a minimum, one should test statistically whether mean participation varies across geographical boundaries within the sample region before estimating a regression model. If the hypothesis of equal means cannot be rejected, the regression approach will be futile and the sample mean becomes the appropriate and certainly most convenient estimator.

The recreation participation model developed here differs from those in the literature first by using the household as the sample unit and by focusing on recreation trips as a composite variable and then explaining the composition of a trip by activity. The conceptual rationale for focusing on the household is that recreation decisions may often be joint decisions where the entire family participates. The probable interdependent decisionmaking within the family suggests that the household is a more appropriate unit for analysis than the individual. The statistical benefit of focusing on households is the increased probability that at least one member of the household participates in recreation.

By considering a composite of recreation activities, the probability that someone in the household participates is again increased. A zero response is obtained only when no one in the household participates in any of the four activities. The number of zero responses in most studies and the conventional two-step estimation procedure is no longer necessary.

More than one recreation activity is often undertaken during one recreation trip. For example, during a weekend camping trip, some family members may fish and boat while others swim, and some family members may enjoy each activity. The demand curve for recreating by a single activity may be different from one for the same activity where other activities also occur. The interdependence of recreation activities will be considered by analyzing recreation trips as a composite and then explaining the activity composition of these trips.

Consider first the possibility that the most appropriate recreation participation estimator is the sample mean of trips per household. The hypothesis that populations have the same participation rate can be tested by a one-way analysis of variance. The formal statistical hypothesis is that the mean number of trips per household is constant across subregions within the total region. The first test is whether the mean number of trips per household is constant across the three states. The sample means equal 5.5, 5.5, and 8.6 for Oregon, Idaho, and Washington, respectively, for summer trips and 1.6, 1.3, and 2.9 trips per household for winter trips. The observed F statistics are 20.23 (summer) and 17.55 (winter), which reject the hypothesis of equal means across the three stages.

The second test is whether the mean number of trips per household is constant across counties for the 40 counties sampled. The observed F statistics are 3.67 (summer) and 2.90 (winter), which are larger than expected at the 95 percent level if the means were constant. The third hypothesis is that means are equal across counties where counties are grouped by state. Reporting the summer F values first and the winter values second, the F statistics are 2.42 and 2.90 for Oregon, 5.11 and 1.85 for Idaho, and 1.93 and 1.18 for Washington.

Each of these F values suggests rejecting the hypothesis of equal means at the 95 percent level. However, some of the F values are close to their theoretical value, which is not true of the above two tests.[1]

The implication of these tests is that recreation participation (in camping, fishing, boating, and swimming) differs across the three states in the region and between counties within each state. The main source of this variation comes from Washington residents who recreate more on the average than Oregon and Idaho residents.

Because mean trips per household are apparently not constant across counties in the region, the nonrandom variation in household trips should be explained. The number of trips per household (summer plus winter) is postulated to be a linear function of demographic and recreation supply variables. The only demographic variables included in the model are household size and household income, because these are the only demographic data for which data were collected.

The relevant supply measure of recreation opportunities includes the necessary recreation facilities and the distance of these facilities from the population centroid. The recreation facilities used here are: number of camping units, boat ramps, linear designated beach feet, and river-plus-shoreline miles for camping, boating, swimming, and fishing, respectively. The recreation supply variables, defined as recreation accessibility, are estimated as a function of the availability of facilities, and the willingness to travel the necessary distance to these facilities. Let F_{ij} denote the probability of driving the distances from population centroid i to the jth recreation centroid. The recreation accessibility of each population centroid (RA_i) for one activity is estimated by summing recreation facilities (Fac_j) over all recreation centroids in the region weighted by the probability of driving the corresponding distances. That is,

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[1] An examination of the raw data indicated that six households reported taking more than 150 trips during either the summer or winter. These observations were treated as outliers and the analysis of variance tests were rerun. Even after omitting these six observations, all the above hypotheses were rejected at the 95 percent level.

$$RA_i = \sum_{j}^{195} F_{ij}\ Fac_j \tag{III.5}$$

where i = 1, 2, ..., 155 and where RA_i measures the accessibility of recreation opportunities to the ith population centroid. Equation (III.5) must be estimated separately for each of the four activities because the friction factors (F_{ij}) and facilities are unique to each activity. Using Eq. (III.5), recreation accessibility was estimated for each activity and for each population centroid in the region.

As a measure of the supply of recreation opportunities, recreation accessibility has some commendable properties. First, every recreation destination in the region is considered in this measure. Second, these opportunities are summed, but weighted by the probability of driving the necessary distance. Limitations of this measure are the data requirements to estimate it and that congestion is ignored.

From the above-defined variables, the trip production model is expressed as

$$T_i = f\ (HS_i,\ Y_i,\ RA_c,\ RA_f,\ RA_b,\ RA_s,\ D_1,\ D_2) \tag{III.6}$$

where the variables are defined as:

T_i = number of trips produced by household i,

HS_i = number of people in household i,

$RA_{c,f,b,s}$ = recreation accessibility for camping, fishing, boating, and swimming,

D_1 = dummy variable = 1 if Oregon, and 0 otherwise, and

D_2 = dummy variable = 1 if Idaho, and 0 otherwise.

The state dummy variables are included because the analysis of variance tests revealed recreation participation rates vary across states.

The number of households surveyed exceeded 3,000, which yielded more data than is necessary for regression analysis. Those respondents who failed to answer a question, particularly on family income, were deleted as were one-half of the remaining responses. Using a sample size of 1545 households, a trip-production model is estimated to be:

$$\text{(III.7)} \quad T_i = 5.71 + \underset{(4.35)}{0.983}\, HS_i + \underset{(3.84)}{0.879}\, Y_i + \underset{(0.14)}{0.0001}\, RA_s - \underset{(-2.55)}{0.014}\, RA_c + \underset{(0.14)}{0.0008}\, RA_f + \underset{(2.01)}{0.346}\, RA_b - \underset{(-1.25)}{1.695}\, D_1 - \underset{(-2.83)}{3.345}\, D_2$$

where t values are in parentheses and $R^2 = 0.053$. The encouraging results from Eq. (III.7) are that household size and income have positive coefficients that are highly significant. Unfortunately, only one recreation accessibility variable (boating) is significant and of proper sign.

The main purpose of Eq. (III.7) is to estimate the number of trips per household for each population centroid in the region. Because the model will be used for estimating purposes, it should not contain insignificant coefficients. After eliminating the insignificant variables, the model becomes

$$\text{(III.8)} \quad T_i = 5.005 + \underset{(4.399)}{0.993}\, HS_i + \underset{(3.846)}{0.876}\, Y_i - \underset{(-4.709)}{4.084}\, D_1 - \underset{(-3.865)}{3.053}\, D_2$$

where $R^2 = 0.049$, and where household size and income remain highly significant. The negative coefficients for the dummy variables are consistent with the analysis of variance result that participation rates differ across the three states.

The recreation accessibility variables do not appear in Eq. (III.8) because they are not significant. Recreation facility variables are subject to serious measurement errors, which at least partially explains their estimated insignificance. An implication of the insignificance of the accessibility variables is that increasing recreation facilities will not cause people to increase their participation, although they may redistribute their demand for recreation sites.

Equation (III.8) is used to estimate the expected number of recreation trips produced by household for each county in the three-and-one-half state region and western Montana. Census data for 1980 on household size by county and 1979 Department of Commerce county income data were substituted into Eq. (III.8) to estimate trips per household by county. The number of households by county--obtained from the 1980 census--was multiplied by trips per household to estimate total trips per county.[2]

The Oregon State University survey data were also used to allocate total recreation days by county to the four activities: camping, fishing, boating, and swimming. Treating each state separately, frequency distributions were constructed showing the proportion of days of participation in each activity (see Table B.1 in Appendix B). These proportions were then multiplied by total recreation days by county to estimate number of days by activity for each county.

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[2] Total county trip data were transformed into total recreation days by first multiplying trips by the average length of stay. For Oregon, Idaho, and Washington, the sample survey estimates are: 2.439, 2.194, and 2.453 days per trip, respectively. The average size of a recreation party is estimated to be the mean household size, which is 2.60, 2.85, and 2.61 for Oregon, Idaho, and Washington according to the 1980 census. Total recreation days per county are estimated as the product of total trips, average length of stay, and number of persons per trip. For the three-state region, households average about 8.6 trips per year and, considering household size and length of stay, about 55.4 recreation activity days per year.

Estimates of activity days were also constructed for ten counties in western Montana. Regional mean sample data were used to produce these estimates. The estimates of recreation trips produced by activity and by population centroid appear in Appendix A, Table A.3.

C. Attractions Model (A_j)

The gravity model also requires an estimate of the attractions (quantity demanded) of each recreation centroid. Attractions are postulated to be an exponential function of recreation facilities and the accessibility of the recreation centroid, which measures the likely demand on that centroid. Demand for recreation sites tend to vary inversely with the distance to population centers. The responsiveness of attractions to changes in facilities should therefore be positively related to the nearness of these facilities to population centers. Furthermore, attractions should respond to increments in facilities at a diminishing rate, because demand cannot increase indefinitely in proportion to facilities. The attractiveness model is specified in exponential form to allow for the diminishing returns effect and the interaction between facilities and accessibility.

Accessibility of recreation centroids, called population accessibility, is a function of the number of trips produced by each population centroid and the likelihood that these trips will terminate at that recreation centroid. The accessibility of each recreation centroid is estimated by summing trips produced (P_i) by all population centroids weighted by the probability of driving the distance to the recreation centroid. That is, population accessibility for the jth centroid is

$$PA_j = \sum_{i}^{155} F_{ij} P_i \qquad \text{(III.9)}$$

where the F_{ij} values are obtained from the decay curves. Estimates from Eq. (III.9) were constructed for each recreation centroid in the region and for each of the four activities being analyzed. Population accessibility estimates are one input in the recreation attractiveness model.

The attractiveness model also assumes that demand at a site is a positive function of the site characteristic. The facility variables used are camping units, river and shoreline miles, boat ramps, and linear designated beach feet for camping, fishing, boating, and swimming, respectively. U.S. Forest Service data on visitor days and facilities by ranger district were used with the accessibility data obtained from Eq. (III.9) to estimate the attractiveness model. As seen in the first four rows in Table 2, the accessibility coefficients are significant in only two of the four equations. This insignificance is due partially to poor quality data because similar estimates based on older survey data showed this variable to be significant. The positive accessibility coefficients indicate that use for each activity is greatest for those sites located near large production centroids. The facility variables are overall significant and have positive signs as expected. As the equations are in multiplicative form, a positive accessibility exponent implies that the responsiveness of use to facilities is positively related to the accessibility of a site. That is, for a given increment in facilities, use will be greatest for those sites that are most accessible. Facility and accessiblity data for each recreation centroid were substituted into Eq. (III.10)-(III.13) to estimate relative attractiveness of each centroid in the region. The sum of attractions to all sites estimated by the attractions model will not likely equal total

TABLE 2

REGRESSION ESTIMATES OF EXOGENOUS AND ENDOGENOUS ATTRACTIONS (in natural logs)

Equation Number	Activity	Intercept	Recreation Facility	Recreation Access.	Coef. of Det. Sample Size
(III.10)	Swimming	1.060 (0.943)	0.194 (2.902)	-0.216 (-0.721)	$R^2 = 0.18$ $n = 42$
(III.11)	Camping	-0.396 (0.372)	0.631 (5.460)	0.466 (2.123)	$R^2 = 0.41$ $n = 49$
(III.12)	Fishing	-5.637 (-2.408)	0.533 (15.862)	0.354 (1.956)	$R^2 = 0.78$ $n = 74$
(III.13)	Boating	1.242 (0.698)	0.586 (3.363)	0.691 (1.394)	$R = 0.25$ $n = 36$
(III.10')	Swimming	-4.052 (-2.309	0.163 (2.585)	0.576 (2.487)	$R^2 = 0.29$ $n = 42$
(III.11')	Camping	-2.763 (-2.315)	0.509 (4.781)	0.591 (3.955)	$R^2 = 0.52$ $n = 49$
(III.12')	Fishing	12.020 (2.419)	0.545 (16.199)	0.248 (2.636)	$R^2 = 0.79$ $n = 74$
(III.13')	Boating	-9.716 (3.730)	0.621 (4.287)	1.408 (4.210)	$R^2 = 0.47$ $n = 36$

Note: the numbers in parentheses are t values. The dependent variables are activity days for swimming, camping, fishing, and boating, respectively. The first independent variable is the facility variable, which is linear designated beach feet (BF_j), camp sites (CS_j), acceptable river miles (RM_j), and boat ramps (BR_j). The second independent variable is accessiblity for swimming, camping, fishing, and boating, respectively.

trips produced in the region. An accounting identity and condition of the gravity model is that total trips produced equals total trips received. The attractions model therefore estimates relative attractiveness, and these attractions are scaled to sum to total trips produced.

The three inputs in the gravity model, P_i, A_j, and F_{ij} have been estimated with a trip production model, a trip attractions model, Eq. (III.10)-(III.13), and by transforming the impedance matrix with the decay curves. The output of the gravity model is a trip interchange matrix (T_{ij}) that gives the number of trips emanating from population centroid i with recreation centroid j as the destination.

The statistical estimates of the attractiveness model are unimpressive in terms of overall explanatory power and in the failure of the accessibility variable to be positive and significant. Recreation data are typically of low quality and the data used in the attractiveness model are no exception. In addition, there may be a specification problem with the attractiveness model. The gravity model has the desirable property of distributing trips according to the attractiveness of a recreation site relative to all substitute sites in the region, and according to effect of distance to the site (R_{ij}), relative to all sites in the region. The gravity model includes the effect of substitute sites in terms of relative travel distance (or travel time) and relative attractions. Incorporating this property into the attractiveness model would be highly desirable. Because one input for this extension results from calibrating the gravity model, a discussion of this calibration procedure is provided first.

3. Calibrating the Gravity Model

A trip interchange (T_{ij}) matrix is illustrated in Table 3. A row depicts the number of trips received by each destination centroid emanating from a given origin. Similarly, the columns depict the number of trips emanating from each population centroid with a given destination. Because the region is defined to be closed, the total number of trips produced must equal the total number of trips received, which in turn equals the total sum of trips in the trip interchange matrix.

Unfortunately, the best estimates of T_{ij} are not obtained simply by substituting the input data into the gravity model [Eq. (III.1)] and solving. First,

TABLE 3

TRIP INTERCHANGE MATRIX

j	Trip Interchange Matrix (T_{ij})						Trip Productions P_i
i	1	2	.	.	.	m	
1	T_{11}	T_{12}	.	.	.	T_{1m}	$\sum_j T_{1j} = P_1$
2	T_{21}	T_{22}	.	.	.	T_{2m}	$\sum_j T_{2j} = P_2$
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
n	T_{n1}	T_{n2}	.	.	.	T_{nm}	$\sum_j T_{nj} = P_m$
Trip Attractions A_j	$\sum_i T_{i1} = A_1$	$\sum_i T_{i2} = A_2$	.	.	.	$\sum T_{im}$	$\sum_j^m A_j = \sum_i^n P_i = \sum\sum_{ij} T_{ij}$

the estimated trip-length (miles one way) frequency distribution obtained from using the estimated T_{ij} values and the impedance matrix typically would not correspond with the assumed known distributions, that is, the decay curves. Second, the estimated number of trips received at each recreation centroid would not correspond with the attractiveness input data, which means that the sum of the column vectors in Table 3 would not equal A_j.

The gravity model is therefore calibrated with an iterative technique where a new trip interchange matrix (T_{ij}) is estimated by each iteration. The elements of the new T_{ij} matrix are used to estimate a trip-length frequency distribution and are summed vertically to estimate A_j. These estimates are compared with the assumed known decay curves and A_j values, and if a significant discrepancy exists, the iterative process continues. The gravity model is calibrated to produce a T_{ij} matrix that yields a decay curve corresponding to the exogenous decay curve and estimated attractions that correspond to exogenous attractions. When the estimated and observed A_j values and decay curves are satisfactorily close, as judged by some predefined criteria, the iterations conclude.

To define this calibration technique more precisely, recall that the conventional gravity model includes the constraint, Eq. (III.2), which in terms of Table 3 is

$$\sum_{i}^{M} T_{ij} = A_j \quad \text{, for each } j. \tag{III.14}$$

Each iteration of the gravity model necessarily satisfies the production constraint, Eq. (III.2), because the ratio component of Eq. (III.1) sums to one. However, Eq. (III.14) is not generally satisfied by the first or even second iteration. The calibration technique brings the estimated and observed trip-length distributions together and also satisfies Eq. (III.14). In each iteration, attractions are multiplied by the coefficient b^c, which reflects the discrepancy between A_j and $\sum_i T_{ij}$ estimated in the previous iteration. This adjustment coefficient is obtained from

$$b^c = b^{c-1} \frac{A_j^{c-1}}{\sum_i T_{ij}^{c-1}} \tag{III.15}$$

where c designates the number of the iteration. The attractions for each iteration after the first iteration are estimated by multiplying the previous attractions by the adjustment coefficient obtained from Eq. (III.11). This procedure results in Eq. (III.10) being approximately satisfied.

According to this conventional calibration technique, the number of trips received by each recreation centroid is exogenous, and the gravity model solves for the distribution of recreation travel. The number of trips received by each recreation centroid is estimated by the attractiveness model, Eq. (III.10)-(III.13), on the basis of facilities at the site and accessibility of the site. The attractiveness model, as defined thus far, does not consider the effect of substitute sites as does the gravity model.

A procedure similar to Eq. (III.15) is used to adjust the friction factors F_{ij}. The travel distance factors used in the cth iteration ($F_{ij}{}^{c}$) are equal to the product of the factors used in the previous iteration ($F_{ij}{}^{c-1}$) and the ratio of observed to calibrated trips which occur from i to j. That is,

$$F_{ij}{}^{c} = F_{ij}^{c-1} \frac{OD}{GM} \tag{III.16}$$

where the numerator is the percent of trips implied by the decay curves and GM is the percent of trips for the same distance that is predicted from the gravity model. The gravity model is calibrated using an iterative approach as defined by Eq. (III.15) and (III.16). Three iterations are generally required for the trip interchange matrix (T_{ij}) to approximately satisfy the attractions constraint, Eq. (III.3), and to produce a decay curve that closely corresponds with the observed decay curve.

The empirical estimates of the attractiveness model in Table 2 are disappointing, particularly because two of the accessibility coefficients failed to be significantly positive as expected. Recall that accessibility is estimated as the sum of trips produced weighted by the F_{ij} values, which are probabilities of driving various distances. The F_{ij} values are estimated from decay curves, which in turn are estimated with regionwide trip-length data. The decay curves are probably an accurate representation of recreation travel overall, but they are not necessarily accurate for any individual site. If a recreation site is close to a large urban area, most trips will have short travel distances, and the tail of the decay curve will terminate close to the origin. Alternatively, if all origins to a site are several miles away, the appropriate decay curve must reflect a large area under these corresponding distances.

The attractiveness model estimated above presumed that a decay curve estimated with regionwide data would be applicable to each site. A preferred alternative is to estimate a decay curve for each site which reflects the influence of substitute sites.

The gravity model produces a T_{ij} matrix (Table 3), but it also estimates an F_{ij} matrix via the iterative procedure. An F_{ij} matrix is a gravity model input variable and it is based on a single regional decay curve. The algorithm for computing T_{ij} is iterative, and it continues to adjust the F_{ij} values until estimated attractions balance with A_j and the decay curve implicit in the T_{ij} matrix balances with the regional decay curve. The iterative calibration process [Eq. (III.16)] results in a new F_{ij} matrix in each iteration. Implicit in this matrix is a decay curve that is unique to each site. The final iteration produces an F_{ij} matrix where each column vector implicitly contains a decay curve unique to the corresponding destination. As these F_{ij} values are computed by the gravity model, they reflect the influence of the independent variables in the gravity model.

The gravity model was estimated using the input variables defined above, including the attractiveness variables predicted from Eq. (III.10)-(III-13) in Table 2. From this version of the gravity model, the estimated F_{ij} values were obtained. These values were then used to reestimate the recreation accessibility measure and then to reestimate the attractiveness model.

Empirical estimates of the second version of the attractiveness model appear as Eq. (III.10')-(III.13') in Table 2. The explanatory power of the model, as measured by R^2, shows an improvement in each of the four equations over the previous estimates. Each of the accessibility coefficients is positive and is significant at the 1 percent level. Overall, on empirical grounds, this two-stage procedure for estimating the attractiveness model results in a dramatic improvement in the model.[3] On theoretical grounds, the model is also improved because the same varibles that determine the distribution of recreation travel also influence total demand at each site. In addition to being a distribution model, the gravity model, along with the attractiveness model, becomes a trip demand model.

The gravity model as estimated in this study produces two outputs necessary to estimate demand and benefits for recreation sites. First, quantity demanded is estimated for each centroid and for each of the four activities. By changing the level of facilities at a centroid, the attractiveness of the centroid changes [Eq. (III.10')-(III.13')] and, through the gravity model, so does the total number of trips received. For each recreation centroid, the gravity model also estimates the number of trips received from each origin. These data are transformed into visit rates and are a critical output in estimating travel-cost demand curves. Estimating a gravity model requires constructing an impedance matrix, which reflects the minimum travel distance from each origin (population centroid) to each destination (recreation centroid) in the region. These minimum travel distances, when multiplied by travel cost per mile, yield travel-cost estimates that are necessary to estimate recreation demand curves.

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[3] Three of the four equations in Table 2 use data from only 49 ranger districts, whereas the fishing equation is based on 74 observations. Destinations on the original highway network conformed to only 49 ranger districts. When this network was expanded to include all ranger districts, and a larger impedance matrix was constructed, the new attractiveness equation (except for fishing) failed to show a statistical improvement. For this reason, only the new fishing equation is used.

CHAPTER IV

ESTIMATING AN OUTDOOR RECREATION DEMAND CURVE

In Chapter II recreation benefits are defined as net willingness to pay, or alternatively as consumers' surplus, and measured as the area under a recreation demand curve and above the market price. A detailed explanation of the travel-cost method of estimating a recreation demand curve is presented in Section 1 in this chapter. Recreation demand curves and net willingness to pay are estimated for each of 195 recreation centroids and for each of the four activities being studied. A gravity model of recreation travel was developed in Chapter III. The purpose of this model is to estimate recreation trips by origin to each site in the region, and thereby to provide an input in estimating travel-cost demand curves. A sample of these demand estimates is presented in Section 2 of this chapter. Section 2 also includes a discussion of the significance of substitute sites as well as disaggregating recreation into four specific activities.

1. Estimating a Travel-Cost Demand Curve and Consumer Surplus: An Overview

Willingness to pay for a recreation site can be estimated directly or indirectly. In the direct approach an interviewer confronts the recreationist, and using an appropriate survey instrument, asks the recreationists their willingness to pay. There are some numerous and impressive case studies of the direct approach, but for purposes here, it has two serious limitations. An expensive and time-consuming survey must be undertaken for each site analyzed. Also, it is particularly difficult to estimate potential benefits of a site which doesn't exist or to estimate increased benefits from the potential improvement of a site. The critical need to assess potential benefits over a large number of sites precludes the use of direct estimates of willingness to pay.

In the travel-cost method (TCM), willingness to pay is estimated indirectly on the basis of observed travel patterns, and not, as in the direct approach, from what people say they would do in response to hypothetical situations. For this reason, most analysts have preferred the travel-cost approach to the direct approach. Although the TCM has numerous limitations, some of which will be dealt with here, it will serve as the basis for estimating recreation demand and value. The rationale for using the TCM is first its credibility, which results from its widespread use and official sanction by the Water Resources Council (1979). The objective of this study is to develop, test, and apply a model that can estimate recreation demand and value at any site in a large region. There are no viable alternatives to the TCM in terms of models that are theoretically sound and operational on a regional basis.

In this study, travel-cost demand curves are estimated for each of four activities (fishing, swimming, camping, and boating) and for a large number of sites, which are termed recreation centroids. A travel-cost demand schedule is now developed, but the notation is simplified by assuming one activity and one recreation centroid. Let T_i be the annual number of visitor days emanating from the ith population centroid and recreating at the site being analyzed, and let N_i be the population of the ith population centroid. Using C_i for the travel cost per person per visitor-day from the ith zone, the equation

$$T_i/N_i = f(C_i) \tag{IV.1}$$

relates visit rates to travel costs. Equation (IV.1) is the general form of what Clawson (1959) termed the demand curve for the recreation experience, and it is often referred to as a per capita demand curve or visit-rate schedule. The regression estimate of this equation is used to generate a site demand curve by first multiplying the equation by the population of the ith zone (N_i) to obtain

$$\hat{T}_i = f(C_i)N_i \quad ,$$

then summing all origins to obtain

$$\sum_i \hat{T}_i = \sum_i f(C_i)N_i \quad , \tag{IV.2}$$

which yields an estimate of total visitor-days as a function of total travel costs.

The essence of the TCM is that a site demand curve is inferred from the empirical relationship of visit rates by origin to corresponding travel costs [Eq. (IV.1)]. Although travel costs are a transaction cost, not a market price, they are treated as an implicit market price. The response of total recreation days to hypothetical prices is obtained by assuming that recreationists would respond to prices (entrance fees) just as they respond to the same change in travel costs. To estimate total visitor-days as a function of increased travel costs or market prices, ΔP is inserted in Eq. (IV.2) to obtain

$$\sum_i \hat{T} = \sum_i f(C_i + \Delta P)N_i \quad . \tag{IV.3}$$

The prices for a site demand curve may be selected somewhat arbitrarily,[1] but should begin at zero and cover the full range of the demand curve. The quantity of visitor days demanded at each price is obtained from Eq. (IV.3) by letting each price equal ΔP and solving for the corresponding quantity (ΣT_i). A recreation site demand curve can then be estimated from these price-quantity observations. The site demand curve is usually estimated as a regression equation obtained from the price-quantity points. The final step is to estimate consumers' surplus, which is typically the integral of the estimated demand equation.

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[1] The issue of the sensitivity of consumer surplus estimates to the size of price increment is considered in Chapter V.

The focus of this study is on total quantity demanded at a zero price and on consumers' surplus, but not on the site demand curve per se. Furthermore, using regression analysis to estimate a site demand curve raises the issue of the proper functional form. Also, a regression estimate may be highly sensitive to the choice of hypothetical prices substituted in Eq. (IV.3). Because a site demand curve is unnecessary and regression analysis introduces some potential problems, an alternative procedure is developed.

The following chapter will demonstrate that a semilog form of the visit-rate demand schedule is reasonably good and superior to that of the double-log form. Using this form, Eq. (IV.1) becomes

$$\ln (T_i/N_i) = \alpha + \beta C_i + \varepsilon_i \quad . \tag{IV.4}$$

Taking antilogs of the regression estimate of Eq. (IV.4), multiplying by N_i, and summing yields

$$\sum_i T_i = e^{\hat{\alpha} + \hat{\beta}(C_i + \Delta P)} \quad , \tag{IV.5}$$

which corresponds to Eq. (IV.3). The price increments used here are \$1 from \$0 to \$4, \$2 from \$4 to \$12, \$4 from \$12 to \$76, or until a successive price increment increases consumers' surplus by less than one percent. Initially, one-dollar price increments were used from \$0 to \$76, but experimentation showed that most of the consumers' surplus occurs at relatively low prices. Also, extensive computer time is required to perform the large number of calculations required for 780 (195 x 4), first-stage demand curves. For these two reasons, larger price increments were used as higher prices.

The hypothetical prices and the quantities generated from Eq. (IV.5) can be used to estimate recreation demand and value.[2] In lieu of estimating the site-demand curve, consumers' surplus is estimated directly by applying Bode's Rule to the price-quantity data. Bode's Rule is an algorithm for integrating a fourth degree polynomial that fits five points equally spaced on the horizontal axis. Suppose that we are given five such points x_i, where $i = 0, \ldots, 4$. Bode's rule approximates

$$\int_{x_0}^{x_4} f(x)\, dx$$

by fitting a fourth degree polynomial through the five points $(x_i, f(x_i))$. Bode's Rule is[3]

$$\int_{x_0}^{x_4} f(x)\, dx = \frac{2h}{45}(7f_0 + 32f_1 + 12f_2 + 32f_3 + 7f_4) + E$$

$$\text{where } E = \frac{8f^6\ \zeta\ h^7}{945},\ x_0 < \zeta < x_4 \quad .$$

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[2] The approach here follows Clawson's original two-step method of estimating a visit-rate schedule and using it to generate a site-demand schedule, except that the integral of the site-demand schedule is estimated without actually estimating that schedule. An alternative and simpler approach would be to integrate the first-state curve directly.

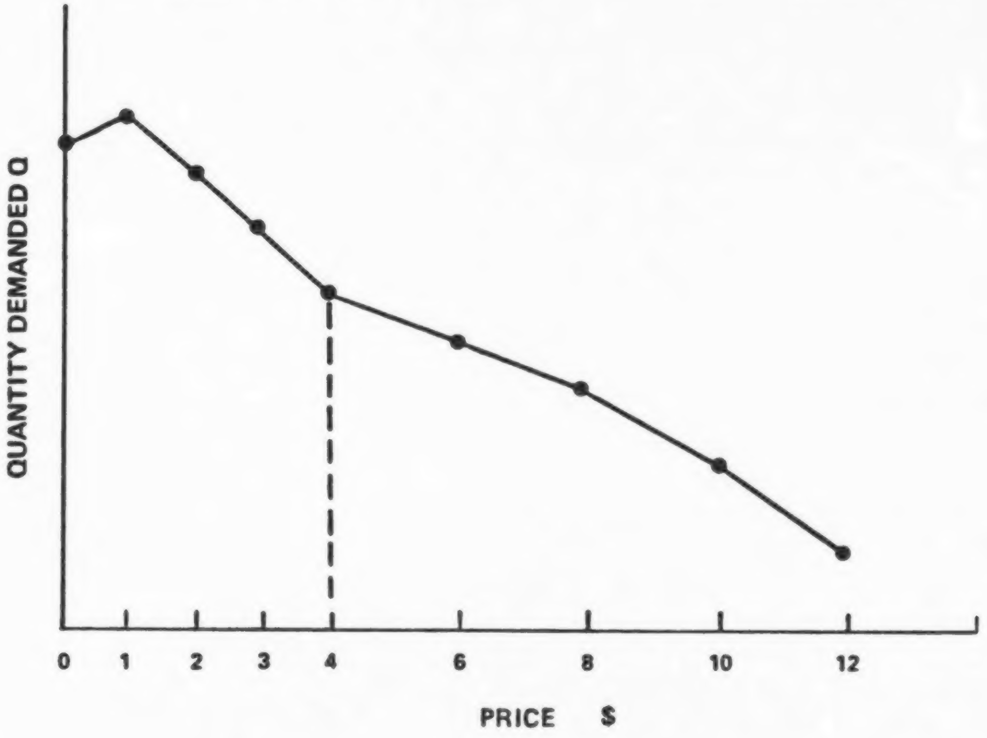
[3] Bode's Rule is given in Davis and Robinowitz (1967, p. 30) and in Abramowitz and Stegun (1964, p. 886).

but the remainder E is set equal to zero. The h term is the interval, which in our case is the price increment used in Eq. (IV.5).

The use of Bode's Rule is illustrated by Figure 7. The first series of five equally spaced points is the prices from $0 to $4 in increments of $1. The corresponding quantities are obtained from Eq. (IV.5). A fourth degree polynomial is connected to these five points, and Bode's Rule is used to measure the area under this segment of the demand curve. The next series of five equally spaced points includes the price-quantity observations where prices ranged from $4 to $12 in $2 increments. Bode's Rule is again applied to estimate the consumer surplus corresponding to this segment of the demand curve. The process continues until the last application of the algorithm increases consumer surplus by less than one percent of the total.

FIGURE 7

ESTIMATING CONSUMERS' SURPLUS USING BODE'S RULE



2. Travel-Cost Demand and Valuation Estimates: Some Illustrations

This study departs from the recreation literature not only in the number of sites considered, but in the number of separate recreation activities. Also, the gravity model permits each site in the region to be considered as a possible substitute for every other site in the region. This section first presents a brief discussion on aggregating recreation activities and then discusses the issues of substitute sites. The model is illustrated by presenting some demand and value estimates of swimming.

A. Aggregating Recreation Activities

In most recreation analyses, recreation is construed as a single homogeneous good. Such an assumption may be appropriate when estimating the demand for a national park, but it is inappropriate when analyzing the demand for water-based recreation. In this study, recreation is disaggregated into four activities: swimming, fishing, boating, and camping. The first three activities are water dependent and camping is water related. In the Northwest, most camping occurs near water, and camping is therefore a potential benefit of improving water quality or of constructing water recreation areas.

The optimal degree of disaggregation is a matter of judgment because increased reliability and realism must be weighed against costs, complexity, and lack of data. It is important to consider the above activities individually because they often occur separately; they have different trip-length frequency distributions and they respond to different water-quality parameters. For instance, an increase in water temperature may be lethal to cold-water fish, but may enhance water quality for swimming.

None of the four activities is homogeneous, implying that even further disaggregation could be useful. For instance, kayaking is a specialized type of boating requiring rapidly flowing water, and this activity is quite different from speed boating or sail boating. Similarly, fishermen may have quite different preferences for salmon, trout, and catfish. Data requirements preclude disaggregating activities beyond the four being considered, and therefore a qualification is required. If a change in water quality affects one type of activity that is not representative of the general category, the model will not produce reliable results. For instance, if an exogenous change affects kayaking, where willingness to pay exceeds that for boating in general, the model will produce valuation estimates with a downward bias.

B. Substitute Sites

According to the economic theory of consumer behavior, the quantity of a good demanded depends on the price of the good, the budget constraint and the price of substitute goods. The conventional travel-cost analysis excludes the price of substitutes and this omission is one of the more serious limitations of the analysis. At least three issues are associated with the availability of substitute sites: (1) the correct measure of the increment in consumers' surplus given that consumers' surplus may be redistributed from a substitute site; (2) the statistical bias in the travel-cost demand curve; and (3) estimating the response of use to a quality or facility change given the attractiveness of alternative sites. The first issue is discussed in Chapter II, where it is argued on the basis of conventional theory that benefits are measured correctly by not subtracting benefits foregone from substitute sites.

The omission of the price of substitutes may introduce a statistical bias into the price coefficient estimate. For those recreationists located relatively near a site, there are likely to be few substitute sites, hence their demand schedule may be relatively inelastic. As we consider travel zones farther from the recreation site, the number of substitute sites increases and the price elasticity correspondingly diminishes. The relationship between visit rates and travel costs may therefore produce a biased estimate of price elasticity.

This bias is one reason for the recent interest in regional models. Dwyer, Kelly, and Bowes (1977), in their review of the recreation demand literature, conclude that regional models are an improvement over single-site analyses. Regional simultaneous equation models have been constructed by Burt and Brewer (1971) and by Krutilla and Fisher (1975) where six sites were considered in each study. Neither of these models is easily transferable to other regions or activities, nor is it clear that all relevant substitute sites were considered.

The substitute sites considered in most demand analyses are those near the site being analyzed, but this consideration is insufficient. For example, suppose that people travel up to 100 miles to camp and that we are interested in the benefits of a new campground. The market area for the new campground would be within a circle with 100-mile radius with the proposed site in the center. Any existing site within this area is a potential substitute for the proposed site. However, the area encompassing substitute sites that must be considered is significantly larger than the market area for the proposed site. Visitors who would travel up to 100 miles to the new or improved site would travel 100 miles in any direction to an identical site. Consequently, a site 200 miles from the proposed could be a substitute for that site because it would attract visitors who reside half-way between the two sites. If visitors would travel up to x miles to recreate at a new or improved site, the area of potential substitute sites is a circle with radius 2x miles. The number of potential substitute sites is therefore much larger than is commonly recognized. Price elasticity estimates in this study, as in previous studies, may be biased because the influence of substitute sites is not adequately considered.

Recreation analyses are as much concerned with estimating the quantity of recreation demanded as with estimating a price elasticity. The increment in quantity demand at an improved site depends upon the attractiveness of substitute sites and the relative travel distances to these sites. A virtue of the gravity model [Eq. (III.1)] is that recreation trips are distributed simultaneously to all sites on the basis of attractions to each site and the relative effect of spatial impedance. The gravity model permits each site in the region to be a substitute for every other site and the model also considers substitutes in terms of travel distances and attractions.

C. Some Empirical Estimates for Swimming

The data necessary to estimate a travel-cost demand schedule include visits or visit rates by origin and the corresponding travel cost. Visit data by origin are estimated for each site by the gravity model, which is discussed in the previous chapter. The travel-cost data include the travel distance from each population centroid to each recreation centroid and the round trip cost per person per vehicle mile. One-way travel distances are obtained from the impedance matrix, which is explained in Chapter III. According to the U.S. Federal Highway Administration, the total cost per mile for an intermediate size car in 1981 is 23.8 cents per mile. However, the variable cost is 6.6 cents per mile for gas and oil plus 5.6 cents for maintenance, accessories, parts, and tires, for a total of 12.2 cents per mile. This estimate of 12.2 cents was doubled to adjust for round-trip costs and then divided by the average number of persons per vehicle (3.47) to obtain 7.753 cents.[4] The average length of stay is one day for swimming, boating, and fishing, but two days for camping; so 7.753 cents is divided by two to obtain mileage costs for camping activities.

A recreation experience demand function is estimated in semilog form for each of four activities and for each of 195 centroids in the origin (these centroids are defined in Appendix A). Total quantity demanded, consumers' surplus and surplus per trip were also estimated for these activities and centroids. A sample of the demand and valuation estimates for swimming is presented in Table 4. The first three columns in this table identify the recreation centoid by number, county, and name. Linear designated beach feet and recreation accessibility (RA_{bj}) are inputs in the attractiveness model, and A_j are estimated attractions from this model. The gravity model estimates total quantity demanded with Eq. (III.3), and these estimates are presented in column 7 of Table 4. As indicated by column 8, most recreation centroids receive trips from over 100 origin zones. An inspection of the trip interchange matrix (T_{ij}) indicated that the large majority of trips emanate from relatively few origin zones. Columns 9-12 are the first-stage demand statistics and overall show a high level of significance. Consumers' surplus is estimated with Bode's Rule, and surplus per trip is simply total surplus divided by quantity demanded (column 7).

The demand and valuation estimate presented in Table 4 reflect one activity (swimming) out of four being considered, and 20 recreation sites out of 195 in the region. However, the demand and valuation estimates based on this sample are representative of the other activities and of the entire region. The

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[4] The number of persons per vehicle is estimated as the sample mean of the household regional recreation survey. This number is larger than the mean household size in each of the four states in the region.

TABLE 4

DEMAND AND VALUATION ESTIMATES FOR SWIMMING IN SELECTED WASHINGTON CENTROIDS

Recreation Centroid Number (1)	County (2)	Recreation Centroid (3)	Linear Beach Feet (4)	RA_{sj} (5)	A_j (6)	Quantity Demanded (7)	Experience Demand Curve Statistics					Consumers' Surplus $ (13)	Surplus per Trip $ (14)
							NOZ (8)	$\ln \hat{\alpha}$ (9)	$\hat{\beta}$ (10)	t (11)	R^2 (12)		
1	Adams	Northeast Corner	1	413	119,815	109,926	126	7.67	-0.225	-32.3	0.877	436,053	3.96
2	Asotin	Fields Spring St. Park	2000	116	199,415	82,308	134	8.34	-0.225	-31.5	0.872	324,576	3.94
3	Benton	Crow Butte State Park	1850	211	277,589	215,045	135	8.85	-0.243	-31.6	0.873	674,364	3.13
4	Chelan	Lake Wenatchee	200	641	366,156	391,439	125	9.06	-0.239	-39.2	0.914	1,661,722	4.24
5	Chelan	Lake Chelan State Park	870	145	198,291	111,302	116	8.55	-0.242	-37.6	0.907	645,566	5.80
6	Clallum	Bogachiel State Park	1200	129	194,775	49,393	107	8.18	-0.230	-31.8	0.876	260,539	5.27
7	Clallum	Neah Bay State Park	1100	79	145,165	24,431	94	8.14	-0.238	-35.3	0.899	131,485	5.38
8	Clallum	Dungeness State Park	1100	722	517,662	534,887	124	9.34	-0.234	-35.7	0.898	2,515,514	4.70
9	Clark	Battleground State Park	1085	912	590,879	806,747	135	9.29	-0.228	-38.8	0.912	5,435,151	6.73
10	Columbia	Lewis and Clark St. Park	1	219	83,203	80,600	136	7.29	-0.220	-29.0	0.852	196,873	2.44
11	Cowlitz	Merwin Reservoir	1	522	137,210	109,345	121	7.83	-0.231	-36.2	0.900	797,108	7.28
12	Cowlitz	Seaquest State Park	1	881	185,382	229,694	127	8.12	-0.229	-36.7	0.903	1,345,905	5.85
13	Douglas	Chief Joseph	100	111	119,167	65,854	108	8.09	-0.242	-36.3	0.901	454,320	6.90
14	Oerrt	Twin Lakes	400	201	210,193	99,762	122	8.64	-0.244	-33.3	0.885	595,718	5.97
15	Franklin	Lyons Ferry State Park	1000	220	257,529	220,907	139	8.64	-0.230	-31.7	0.873	631,644	2.85
16	Garfield	Pataha Creek	1	167	71,319	44,194	131	7.34	-0.229	-31.8	0.874	151,382	3.42
17	Grant	Potholes State Park	1000	238	269,245	224,317	133	8.89	-0.244	-33.7	0.887	687,471	3.06
18	Grant	Sun Lakes State Park	2930	210	298,494	194,961	130	8.86	-0.237	-35.2	0.895	777,465	3.98
19	Grant	Steamboat State Park	1000	219	256,888	153,903	127	8.73	-0.238	-34.3	0.890	606,162	3.93
20	Gray's Harbor	Bay City	1	576	145,131	118,689	120	7.90	-0.233	-32.4	0.878	613,219	5.16

Notes: Quantity demanded was estimated from the gravity model. NOZ is the number origin zones. The demand curve is specified in semilog form. RA_{sj} measures the swimming accessibility of a recreation centroid divided by 1,000. These estimates were obtained from Eq. (III.13).

consumers' surplus estimate of $4.31 per swimming day is comparable in magnitude to the other activities and of the other recreation centroids.

CHAPTER V

SURVEY ESTIMATES OF THE WILLINGNESS TO PAY TO RECREATE AND THE VALUE OF TRAVEL TIME

1. Introduction

The willingness to pay to recreate can be estimated directly using sample surveys or indirectly by estimating a recreation demand curve and measuring the area under this curve. The indirect demand curve approach is used in this study. Taking a regional household recreation survey in the summer of 1980 afforded the opportunity to include a question on willingness to pay. The objective of obtaining direct estimates of consumer surplus is to compare them to the direct estimates when all other factors are equal.

Recreation travel patterns are influenced by travel cost, which is measured at least partially by vehicle operating expenses. An opportunity cost of travel is foregone time, and recreationists may consider travel time as an additional travel cost, or as a benefit. Empirical evidence from the current household survey on the value of recreation travel time is also presented in this chapter. The objective in presenting these results is to provide empirical evidence on the travel time bias in recreation studies.

2. Direct Willingness-to-Pay Estimates

Obtaining credible estimates of willingness to pay using sample survey is a challenging endeavor. Even at best, the estimates may not inspire much confidence. Obtaining these estimates sometimes involves lengthy and expensive personal interviews using a "bidding game" approach. The approach taken here is much less ambitious. The resources available permitted one question to be included on the questionnaire.

Most recreation benefit studies use either the indirect or the direct approach, but not both. The observed differences between results from these approaches owe partially to the different approaches and to other differences, such as sites analyzed, activities included, and date of study. The objective here is to compare direct willingness-to-pay estimates with indirect estimates of the same activities, region, and time period.

Although the complete household survey is included in Appendix B, the direct willingness-to-pay question is provided here. The question is

> What is the maximum daily use fee you would be willing to pay for this recreation facility rather than forego using it?

We explicitly asked for the daily fee to obtain a consumers' surplus estimate per visitor-day.

The frequency distribution of responses is presented in Table 5. Virtually all the respondents indicated a willingness to pay between \$2 and \$10 per trip to recreate. The mean value per trip is \$5.62, and the mode and median are each \$5. The indirect estimates of willingness to pay obtained in this study are in the \$3 to \$6 range with an average of about \$4.20.

3. The Value of Recreation Travel Time

The essence of the travel-cost approach to estimating a recreation demand curve is that the cost of traveling is an empirical proxy for price and the relationship between travel costs and visit rates is used to impute a site-demand curve. If travel costs are estimated as vehicle operating costs and the

TABLE 5

DIRECT WILLINGNESS-TO-PAY ESTIMATES PER RECREATION DAY

Monetary[1] Value ($)	Frequency	Relative Frequency
0	1	0.0027
1	7	0.0192
2	27	0.0741
3	58	0.1594
4	38	0.1044
5	0	0.2472
6	33	0.0906
7	26	0.0714
8	21	0.0577
9	8	0.0219
10	39	0.1071
11	3	0.0081
12	3	0.0081
13	2	0.0054
14	0	0.0000
15+	8	0.0220
Total	364	1.00

Other statistics are: Mean = $5.619, Median = $5.00, Mode = $5.00, Standard Deviation = $2.93

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[1] The monetary values are less than or equal to these numbers. For example, all estimates above $1 and less than or equal to $2 are recorded as $2.

correct measure of travel costs includes some value of travel time, then the estimated demand curve is a biased representation of the true demand curve.

The above point is well recognized in the recreation literature. The concensus in this literature is that travel time is a positive cost of travel and therefore must be included in empirical estimates of travel-cost demand curves. In one of the more widely quoted studies, Cesario (1976) concludes that the recreation value of travel time is approximately 1/3 the average national wage rate. This study has received the official endorsement of the Water

Resources Council in that the Council recommends use of this value in the travel-cost analyses.

In the infinitely flexible and continuously adjustable world of neoclassical economics, the cost of travel time may be defined in terms of foregone earnings. At the conceptual level, the cost of traveling is its opportunity cost, which is what one gives up in order to travel. The neoclassical view is questionable on empirical grounds, because generally people do not have the flexibility to trade work time for travel time. However, a more fundamental objection to using the wage rate as an opportunity cost can be raised on conceptual grounds. The real cost of foregone work time is not wages, but the utility of income minus the disutility of work. Gross wages are not likely to be a good proxy to the net benefits of employment.

In addition to the conceptual objections to valuing travel time in terms of foregone earnings, there is room for skepticism about the reliability of Cesario's empirical estimate. Cesario's estimate was derived from a literature review of several studies of how commuters value their journey-to-work travel time. Recreation is a leisure time, discretionary activity, which is quite different from the daily required journey-to-work trip. The recreationist has the option of choosing a destination so as to have a positive value of travel time. The commuter is generally rigidly constrained to arrive at a destination not of his own choosing and to do so during peak traffic hours.

The above reservations about the accepted view on the travel time bias led to the inclusion of two questions on the household recreation survey. These questions are:

> Q1. Some people feel that time spent traveling to a recreation site is an inconvenience while others enjoy it. How about you?

1. Enjoyed travel time
2. Prefer to shorten travel time
3. Refused
4. Don't know, no answer

Q2. About how much would you be willing to pay to shorten the total travel time for this last trip by one half?

The total sample size is 2,249, of which 107 respondents refused to answer or did not know. Of the remaining respondents, 1,865 enjoyed their travel time, whereas only 276 would prefer to shorten their travel time. These results suggest that travel time is a net benefit, not a cost. Vehicle operating costs probably overstate recreation travel costs, not understate them.

The objective in question one is to determine whether travel time is a net cost or a benefit. The objective of the second question is to obtain a quantitative estimate of what is presumed to be a cost. The frequency distribution of survey results is presented in Table 6.

TABLE 6

DIRECT ESTIMATES OF THE VALUE OF RECREATION TRAVEL TIME

Boundaries	Frequency	Relative Frequency
0.0 - 2.0	1178	0.888
2.0 - 4.0	23	0.017
4.0 - 6.0	46	0.035
6.0 - 8.0	4	0.003
8.0 - 10.0	2	0.002
10.0 - 12.0	33	0.025
12.0 - 14.0	0	0.000
14.0 - 16.0	12	0.009
16.0 - 18.0	0	0.000
18.0 - 20.0	29	0.022
Total	1327	1.00

Other statistics are: Mean = $1.069, Median = 0.0, Mode = 0.0, Standard Deviation = 3.65

The most impressive result in Table 6 is that 88 percent of the respondents are not willing to pay anything to shorten their travel time by 50 percent. Fewer than 3% of the total respondents are willing to pay more than $5 to shorten their travel time by 50 percent. The results in Table 6 cast doubt that recreationists, at least in the Northwest, perceive their travel time as a cost. The question that now arises is whether recreationists deliberately incur vehicle operating costs in order to spend more time traveling. Unfortunately, the survey evidence is insufficient to answer this question. The main result is that the cost of recreation travel time, at least in the Pacific Northwest, and for the four activities considered, is not positive. On this basis, travel cost will be measured as vehicle operating costs. Of course, these results should not be applied to value travel time by commuters in large urban areas.

CHAPTER VI

THE SENSITIVITY OF TRAVEL-COST ESTIMATES OF RECREATION DEMAND AND VALUATION TO VARIOUS COMPUTATIONAL AND SPECIFICATION ISSUES

The travel-cost demand curves developed and estimated in Chapter IV are based on a semilog form of the first-stage demand curve, origins defined as recreation centroids, and total quantity demanded estimated from a gravity model with endogenous attractions. This chapter uses a Monte Carlo simulation analysis to test the robustness and correctness of some of the input assumptions in the model. Specifically, the focus of this chapter is on three specification and computational choices required by the TCM which may influence estimates of the demand curve and consumers' surplus. The three issues investigated here are (1) the functional form of the first-stage demand curve; (2) the width of the concentric zones; and (3) the estimate of total quantity demanded. The objective is to determine the sensitivity of travel-cost demand and valuation estimates to various assumptions concerning these four points. The method of analysis is to apply the TCM to several sites under various assumptions and to contrast the results.

Applying the TCM and estimating consumers' surplus requires that some assumption be made on each of these points. Choices are often made inadvertently; at least there is little analysis of the sensitivity of the results to variations in the computational procedure. The first section of this chapter contains a brief discussion of the possible significance of the three points. Section 2 contains the empirical estimates of travel-cost demand and valuation estimates under these various assumptions. The conclusions and implications are discussed in Section 3.

1. The Three Issues

Many empirical demand curves in the economics literature are specified in double-log form, perhaps because the coefficients may be interpreted as elasticities.[1] In the recreation literature, the semilog specification is most prevalent, although linear functions have been used.[2] An issue considered here is the relative merit of the semilog and double-log specification of the first-stage demand curve and the sensitivity of the valuation estimates to the choice of these two functional forms.

In the TCM, visit rates from various origins are regressed against corresponding travel costs. Since the pioneering work of Clawson and Knetsch (1966), origins have been defined by a series of concentric rings around the recreation site. For instance, if recreationists travel a maximum of 200 miles and rings are defined every 20 miles, then there are 10 origin zones and 10 observations for the experience-demand schedule. Similarly, if a ring is defined every 10 miles, there will be 20 travel zones and 20 observations for estimating the visit-rate schedule. Alternatively, each population centroid may be construed as a separate origin, and the number of observations is therefore determined by the number of such centroids. A second issue is the sensitivity of the demand and valuation estimates to the definition of the origin zone.

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[1] In their literature surveys on the demand for money, Laidler (1977) and Goldfeld (1973) present empirical estimates in favor of a log-log specification.

[2] Linear demand curves have been used by Burt and Brewer (1971) and by Cicchetti, Fisher, and Smith (1976) because this specification is required by some properties of their models.

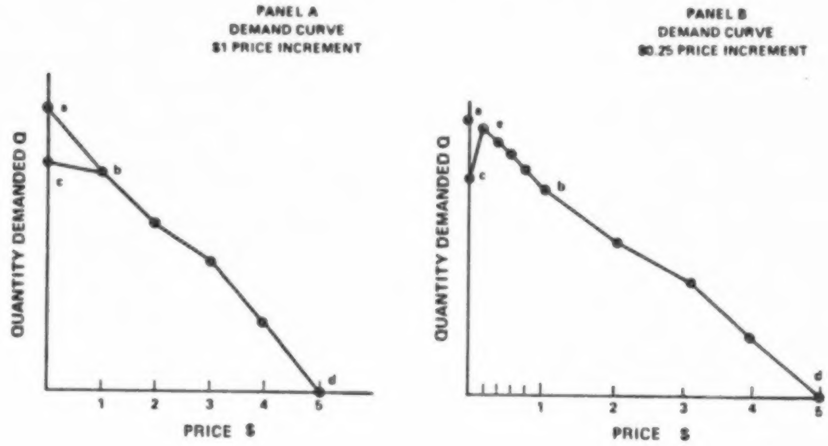
There are at least two ways to estimate total quantity of recreation demanded at a zero price. An estimate can be generated endogenously by substituting a zero price increment in the experience demand curve. Cesario and Knetsch (1976, p. 100) apply this method and it is generally used when site-attendance data are unavailable. In most travel-cost analyses, quantity demanded is estimated exogeneously by site-attendance data. Clawson (1959) estimated quantity demanded in this manner and Knetsch (1974, p. 83) and others have followed his lead. Estimates of consumers' surplus, and particularly consumers' surplus per trip, may be sensitive to the choice between these quantity-demanded estimates.

If the demand curve is constrained to intersect the observed quantity demanded, then the magnitude of the hypothetical price increments in the first-stage demand curve may affect consumers' surplus. Figure 8 depicts a hypothetical demand curve generated from price-quantity observations using $1 price increments in the first-stage demand curve. In Panel A, quantity a is estimated from the first-stage demand curve by letting ΔP = 0, and quantity c is assumed to be the correct estimate. Consumers' surplus estimated as the area under cbd will be less than the surplus estimated as the area under abd. Panel B depicts an estimate of consumers' surplus when price increments of $0.25 are used from 0 to $1, and $1 price increments are used thereafter. If the demand curve is constrained to include the correct quantity demanded, consumers' surplus in Panel B (Oced) exceeds that in Panel A (Ocbd) by an amount equal to ceb. If quantity demanded is estimated incorrectly, the magnitude of the hypothetical price increment could affect the results.

The discussion to this point offers some *a priori* possibilities that specification and computational choices in estimating a travel-cost demand curve may affect the results. Empirical evidence on the sensitivity of the results to

FIGURE 8

PRICE-QUANTITY OBSERVATIONS FOR A RECREATION SITE DEMAND CURVE



these choices is presented in Section 3 by estimating several travel-cost demand curves under alternative conditions using the model described below.

2. Sensitivity of Travel-Cost Estimates to Various Assumptions

Because the 195 recreation centroids and four activities included in the regional model are more than sufficient for this analysis, we quite arbitrarily consider the demand for boating at 20 Washington recreation centroids, numbered 17.0 to 26.0 (column 1 in the accompanying tables). These centroids include those in King County, which contains Seattle and is heavily populated, as well as sparsely populated counties east of the Cascade Mountains. By including both urban and rural counties in the sample, the travel-cost estimates reflect a diversity of realistic conditions. The rationale for sampling a relatively large number of centroids (20) is that certain adverse consequences may be observed only occasionally, and a large sample increases the likelihood of such a result. Also, results based on a single site may reflect a special case, and be inconsistent with results obtained over a wide range of experience.

The sensitivity of travel-cost estimates to each of the computational issues being considered depends upon the assumption made on the other three issues. The interdependence of these issues precludes analyzing them individually. We consider first the functional form of the first-stage demand curve, focusing on the semilog form and the double-log form. Results will be presented by generating quantity estimates endogenously and by assuming that quantity demanded is exogenous. Travel-cost estimates will then be presented using various size origin zones. We will show that the results are sensitive to the definition of origin zone and this sensitivity in turn depends on the choice of quantity demanded and on the functional form.

A. Functional Form of the First-Stage Demand Curve

The issue of proper form of a recreation demand curve has been studied by Zeimer et al. (1980) and by Smith (1975). The studies are similar in that only one site was considered and a statistical analysis, namely a Box-Cox transformation, was used to statistically estimate the most appropriate functional form. Smith rejected the linear form because it provided a poorer fit of the data than the double-log and semilog form. However, Smith also concluded that even though the latter two forms fit the data and provided reasonable results, each form must be considered inappropriate. Zeimer et al. used the Box-Cox transformation procedure and concluded that a semilog form is appropriate and a linear form is inappropriate, and further that consumers' surplus estimates are highly sensitive to the choice of functional form.

In considering the various functional forms, double-log and semilog (logarithm of the dependent variable) are candidates, but the linear form need not be considered. Ziemer et al. and Smith provide evidence against the linear form, and scatter plots of several sites indicate a distinct curvilinear relationship. The evidence against the appropriateness of the linear form is persuasive, and in this study, we consider the double-log and semilog functional form.

The objective of analyzing these two forms is first to determine if the results are sensitive to the choice of functional form and if so, to determine that of the two forms seems most appropriate. Four criteria are suggested that may be useful in identifying the most appropriate form. First, the coefficients of determination are a relevant but not decisive indicator, particularly if estimated over several sites. Second, estimates of consumers' surplus per trip should be somewhat stable across sites and should be similar to those reported elsewhere in the literature. Third, the first-stage demand curve should estimate closely the known quantity demanded at a zero price when $\Delta P = 0$ is used in Eq. (IV.5). Finally, goodness of fit and consumers' surplus estimates should be insensitive to other computational decisions, particularly if the decisions are made arbitrarily. These properties are not espoused as rigorous statistical criteria that will necessarily determine the unambiguous superiority of one functional form. Because previous studies have not been able to resolve this issue on statistical or theoretical grounds, it is appropriate to employ a Monte Carlo analysis, where a demand curve for several sites is estimated with each functional form and the results are compared.

First-stage demand curves for boating [Eq. (IV.4)] are estimated for 20 centroids using both double-log and semilog forms, where the logarithm is taken of the dependent variable. These estimates are based on population centroids as origin zones, a $1 price increment in Eq. (IV.5), and quantity demanded estimated exogeneously. The results are presented in Table 7. The coefficients of determination, columns 2 and 5, indicate that each form fits the data reasonably well, but the semilog model has more explanatory power in 19 of the

TABLE 7

ANNUAL VALUATION ESTIMATES FOR BOATING IN SELECTED WASHINGTON CENTROIDS USING A SEMILOG AND DOUBLE-LOG FUNCTIONAL FORM

	Semilog Results*			Double-Log Results		
Recreation Centroid Number (1)	R^2 (2)	Consumers' Surplus (in $1000) (3)	Surplus per Day $ (4)	R^2 (5)	Consumers' Surplus (in $1000) (6)	Surplus per Day $ (7)
17.0	0.851	2,163	6.22	0.645	2,757	7.94
17.1	0.863	5,239	5.48	0.605	5,577	5.83
17.2	0.873	5,596	5.12	0.666	11,564	10.58
18.0	0.885	283	4.50	0.724	334	5.31
19.0	0.740	141	4.28	0.660	142	4.78
19.1	0.829	536	6.15	0.686	620	7.11
20.0	0.727	548	5.20	0.582	526	5.00
21.0	0.888	1,008	5.83	0.702	886	5.13
22.0	0.766	15	2.57	0.744	18	3.18
22.1	0.751	27	2.56	0.729	58	5.57
22.2	0.673	34	2.32	0.699	69	4.79
23.0	0.884	228	5.44	0.695	220	5.24
23.1	0.884	231	5.08	0.691	331	7.26
23.2	0.874	1,253	5.78	0.636	1,975	9.12
24.0	0.841	19	2.67	0.781	35	4.97
24.1	0.810	31	2.55	0.740	136	11.05
24.2	0.805	39	2.72	0.747	60	4.11
24.3	0.812	67	2.87	0.747	1,606	68.95
25.0	0.874	205	4.89	0.732	168	4.00
26.0	0.785	52	2.42	0.724	109	5.17
column mean	0.820	886	4.24	0.696	1,360	9.23

* In the semilog form the logarithm is taken of the dependent variable.

20 cases. The semilog surplus-per-day estimates are more stable than the corresponding double-log estimates. Dwyer, Kelley, and Bowes (1977) review several empirical studies of recreation behavior, but only a few of these studies deal specifically with boating. If we presume that other water-based activities have a value comparable to boating or that boating is typical of outdoor recreation in general, we may conjecture on the basis of Dwyer _et_ _al_. that value-per-day estimates below $1 or above $10 are outside the range of many

existing studies. The double-log estimate of surplus per day of $68.95 for centroid 24.3 is clearly untenable, and the double-log surplus-per-day estimates of $10.85 and $11.05 appear suspiciously high.

A few of the surplus-per-day estimates, such as those for centroids 18.0 and 20.0, are insensitive to the choice of functional form, but some estimates are highly sensitive to this choice. This result indicates the inadequacy of analyzing the issue of functional form by considering only one site. The results in Table 7 do not establish that either form is correct or incorrect, but the consistently lower explanatory power of the double-log form and the wide variation in surplus-per-day estimates cast some doubt about the appropriateness of this form.

The sensitivity of the above results to the choice of quantity demanded is observed by reestimating the above equations where quantity demanded is obtained from the visit-rate schedule using a zero price increment. Table 8 compares the results of demand and valuation estimates obtained with a semilog and a double-log form where quantity demanded is estimated endogeneously. The assumed known quantity demanded is in column 2 and the semilog and double-log quantity estimates are in columns 3 and 6 respectively. Several of the double-log form estimates of total quantity demanded contain very large errors. For instance, the double-log form produces an estimate of 111 million boating days at Lake Washington (centroid 17.2), which errs by approximately 110 million days. The quantity estimates from a semilog form are much closer aproximations to total use, but the discrepancies are notable.

Comparing the consumers' surplus and surplus-per-day estimates of the semilog and double-log form (Table 6) indicates dramatic differences in results. Total surplus estimates with a double-log form average about four times those of a semilog form, but the surplus-per-day estimates are considerably smaller for

TABLE 8

DEMAND AND VALUATION ESTIMATES USING A SEMILOG AND DOUBLE-LOG FORM AND ENDOGENOUS QUANTITY DEMANDED

Recreation Centroid Number (1)	Exogeneous Quantity Demanded (in 1000) (2)	Semilog Results: Quantity Demanded (in 1000) (3)	Semilog Results: Consumers' Surplus (in $1000) (4)	Semilog Results: Surplus per Day $ (5)	Double-Log Results: Quantity Demanded (in 1000) (6)	Double-Log Results: Consumers' Surplus (in $1000) (7)	Double-Log Results: Surplus per Day $ (8)
17.0	347	534	2,221	4.16	3,751	3,817	1.02
17.1	956	1,270	4,337	4.20	17,657	10,774	0.61
17.2	1,092	1,354	5,677	4.19	111,807	45,793	0.41
18.0	63	70	285	4.10	572	492	0.86
19.0	33	36	142	3.96	122	169	1.38
19.1	87	134	551	4.11	475	741	1.56
20.0	105	135	557	4.12	882	767	0.87
21.0	113	244	1,030	4.22	800	1,081	1.35
22.0	6	4	14	3.52	15	21	1.37
22.1	10	8	26	3.33	130	95	0.74
22.2	15	9	32	3.73	102	97	0.95
23.0	42	57	233	4.06	389	328	0.84
23.1	45	59	235	4.02	1,279	715	0.56
23.2	217	303	1,280	4.22	10,549	7,003	0.42
24.0	7	5	18	3.60	52	50	0.94
24.1	12	9	30	3.49	1,223	512	0.42
24.2	14	10	38	3.67	84	81	0.97
24.3	23	19	66	3.40	7,081	3,988	0.52
25.0	42	49	207	4.25	91	181	1.99
26.0	21	17	50	2.96	1,015	418	0.41
Mean	166	216	902	3.87	8,234	3,856	0.91

the double-log form. Without a benchmark for comparison, we cannot be certain which estimates are most accurate. Because the double-log form yields gross errors in the quantity estimates, it is possible that similar errors characterize the surplus estimates. Comparing total surplus semilog estimates in Table 7 with those in Table 8 indicates a very close correspondence. The result that total surplus estimates are insensitive to the choice of quantity demanded (given a semilog form) is significant. In contrast, the total surplus and surplus-per-day estimates using a double-log form are highly sensitive to the choice of quantity estimate.

The sensitivity of the valuation results to the size of the hypothetical price increment is analyzed by using a price increment of $0.25 from zero to $1 in the first-stage demand curve and a $1 price increment thereafter. The choice of price increment does not affect the (experience) demand statistics, but it may affect the area under the site demand curve. Table 9 depicts double-log and semilog estimates of total consumers' surplus and surplus per visitor-day for each of the 20 centroids considered, using a $0.25 price increment up to $1. We again observe significant discrepancies between the double-log and semilog results. The double-log surplus-per-day estimate of $133.61 for centroid 24.3 is beyond any tenable limit, and several other double-log results appear unreasonably high. In contrast, the surplus-per-day estimates using a semilog form are between $2 and $6, which is in the area of other studies.

Tables 7, 8, and 9 present a comparison of semilog and double-log results under alternative computational assumptions. A comparison of the average results across the three tables provides one measure of the appropriateness of these two forms. Using a semilog form, consumers' surplus averaged $886, $902, and $897 thousand per site and $4.24, $3.87, and $4.25 per visitor day in Tables 7, 8, and 9 respectively. Using a double-log form, consumers' surplus estimates

TABLE 9

TRAVEL-COST VALUATION ESTIMATES USING A SEMILOG AND DOUBLE-LOG FORM AND A $0.25 PRICE INCREMENT

	Semilog Results		Double-Log Results	
Recreation Centroid Number (1)	Consumers' Surplus (in $1000) (2)	Surplus per Day $ (3)	Consumers' Surplus (in $1000) (4)	Surplus per Day $ (5)
17.0	2,205	6.34	3,503	10.08
17.1	5,307	5.55	8,284	8.66
17.2	5,651	5.17	24,974	22.85
18.0	285	4.52	437	6.95
19.0	142	4.30	159	4.81
19.1	547	6.27	710	8.14
20.0	554	5.27	627	5.96
21.0	1,024	5.93	1,023	5.92
22.0	14	2.50	20	3.56
22.1	26	2.51	82	7.83
22.2	32	2.23	89	6.12
23.0	232	5.53	284	6.76
23.1	234	5.14	536	11.76
23.2	1,272	5.88	3,919	18.09
24.0	19	2.60	45	6.34
24.1	31	2.49	303	24.66
24.2	38	2.66	74	5.12
24.3	66	2.83	3,111	133.61
25.0	206	4.93	177	4.23
26.0	50	2.38	245	11.57
Mean	897	4.25	2,430	15.66

Note: These results are based on an exogenous estimate of total quantity demanded.

per site are $1,360, $902, and $2,430 thousand per site and $9.23, $0.91, and $15.66 per visitor-day. Double-log results are highly sensitive to the choice of hypothetical price increment in Eq. (IV.5) and to the choice of quantity demanded at a zero price. Double-log results also show wide differences across sites, even when computational assumptions are identical. In contrast, the semilog results are relatively stable across sites and much less sensitive to the choice of price increment in Eq. (IV.5) and to the choice of quantity demanded. These results do not support the use of the double-log form and suggest that a semilog form is to be preferred.

B. Size of Origin Zone

When the travel-cost method was presented by Clawson (1959) and by Clawson and Knetsch (1966), origins were aggregated into zones defined by a series of concentric circles. There does not appear to have been any serious analysis of the appropriate size of these origin zones, nor of the sensitivity of the results to various size zones.[8] The above results use each population centroid in the region as a potential origin zone. Evidence on the sensitivity of travel-cost demand and valuation to the definition of the origin zone is obtained by comparing the above results to those obtained using 10-mile and 20-mile origin zones. Consider two systems of concentric circles, one at 10-mile and one at 20-mile intervals from the recreation centroid. Origin zones are now defined as the area between each ring and visit rates are defined as total trips from each zone per 1,000 population of the zone. The travel cost from each zone is the weighted average travel cost of all centroids within the zone where the weights are the number of trips per centroid.

Travel-cost demand and valuation estimates using 10- and 20-mile origin zones are presented in Table 10. Comparing the results using a 10-mile zone with those of a 20-mile origin shows similar estimates for several sites, but quite dissimilar estimates for others. The estimates in Table 10 are comparable to the semilog results in Table 7 because they are based on a semilog specification, a $1 price increment in Eq. (IV.5), and quantity demanded estimated

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[8] Brown and Nawas (1973) have argued that observations should be based on individuals, rather than aggregations of people. As they use site-attendance data, visit rates reflect the frequency of participation of and not the aggregate participation rate of the population.

TABLE 10

SEMILOG VALUATION ESTIMATES USING 10-MILE AND 20-MILE ORIGIN ZONES*

	10 Mile Origin Zones			20 Mile Origin Zones		
Recreation Centroid Number -(1)	R^2 (2)	Consumers' Surplus' (in $1000) (3)	Surplus Per Trip (4)	R^2 (5)	Consumers' Surplus (in $1000) (6)	Surplus Per Trip (7)
17.0	0.675	$1,394	$4.01	0.787	$1,415	$4.07
17.1	0.764	3,463	3.62	0.749	3,606	3.77
17.2	0.768	3,775	3.45	0.868	2,830	2.59
18.0	0.935	111	1.77	0.977	91	1.44
19.0	0.631	82	2.47	0.668	81	2.45
19.1	0.547	444	5.10	0.470	587	6.73
20.0	0.619	394	3.75	0.751	337	3.21
21.0	0.824	767	4.44	0.827	882	5.11
22.0	0.258	117	20.52	0.216	217	38.12
22.1	0.620	60	5.70	0.716	44	4.21
22.2	0.170	361	24.87	0.474	313	21.58
23.0	0.882	118	2.82	0.948	114	2.73
23.1	0.895	120	2.62	0.928	109	2.39
23.2	0.815	890	4.11	0.913	868	4.01
24.0	0.916	9	1.36	0.919	7	0.97
24.1	0.903	53	4.31	0.903	44	3.56
24.2	0.835	29	2.02	0.877	23	1.61
24.2	0.830	139	5.97	0.806	106	4.56
25.0	0.840	98	2.35	0.915	75	1.79
26.0	0.699	102	4.80	0.698	80	3.76
Mean	0.720	$626	$5.50	0.771	$591	$5.93

*These estimates are based on a $1 price increment in Eq. (IV.5), and quantity demanded estimated exogeneously.

exogenously. Comparing the results on these two tables indicates that aggregating population centroids into concentric zones increases consumers' surplus by an average of over $1 per trip. Furthermore, consumers' surplus estimates on Table 7 appear uncorrelated with those on Table 10. Estimates of total surplus for centroids 17.1 and 17.2 are over $1 million lower when population centroids are aggregated into zones. However, the aggregation process increases the surplus estimates per trip for centroids 22.0 and 22.2 by over 300 percent. The surplus-per-trip estimates for these two recreation centroids exceed $20, and the coefficients of determination are relatively lower for these two centroids. The results for these two centroids may be regarded as outliers and therefore dismissed, but it is significant that aggregating population centroids into zones produced outliers whereas use of population centroids as origins did not.

The conclusion that travel-cost valuation estimates are sensitive to the definition of the origin zone raises the question of which definition is most appropriate. The average of the coefficients of determination favor the use of population centroids as origin zones; but the differences in R^2 values between models do not provide sufficient evidence to resolve this issue. The two extreme estimates (centroid 22.0 and 22.2) obtained from the 10- and 20-mile origin zone equations raise a question about aggregating, but are also not compelling evidence against it. A third potential indicator of the proper model is the ability of the statistical estimate of the first-stage demand curve to estimate known quantity demanded at a zero price.

Table 11 depicts the assumed known quantities and endogenous estimates of this variable using 10- and 20-mile origin zones and using recreation centroids as origin zones. The main result is that aggregating population centroids into either 10- or 20-mile zones substantially improves the ability of the model to predict total use at a zero price. Although aggregating populations improves the predictive ability of the model in this sense, the quantity estimates for several centroids still contain substantial errors.

The result that aggregating population centroids into concentric zones does not improve the R^2 values, but does improve the estimates of total quantity demanded, is easily explained. Visit rates diminish with distance from the site, but the number of population centroids increases with distance from the

TABLE 11

ESTIMATES OF QUANTITY DEMANDED BY CENTROID USING SEMILOG AND DOUBLE-LOG FORMS AND VARIOUS DEFINITIONS OF ORIGIN ZONES (IN THOUSANDS OF VISITOR-DAYS)

		Semilog Results			Double-Log Results		
Recreation Centroid Number (1)	Exogeneous Quantity Demanded (2)	Recreation Centroids (3)	Ten-Mile Origin Zone (4)	Twenty-Mile Origin Zone (5)	Recreation Centroids (6)	Ten-Mile Origin Zone (7)	Twenty-Mile Origin Zone (8)
17.0	347	534	352	313	3,751	492	540
17.1	956	1,270	912	829	17,657	1,357	1,381
17.2	1,092	1,354	1,009	833	111,807	1,656	1,333
18.0	63	70	47	34	572	56	44
19.0	33	36	32	27	122	45	59
19.1	87	134	97	87	475	134	155
20.0	105	135	114	98	882	261	240
21.0	113	244	148	145	800	243	337
22.0	6	4	18	24	15	34	51
22.1	10	8	18	14	130	39	48
22.2	15	9	43	40	102	101	113
23.0	42	57	37	31	389	48	51
23.1	45	59	39	33	1,279	55	50
23.2	217	303	206	185	10,549	345	325
24.0	7	5	7	4	52	6	4
24.1	12	9	26	21	1,223	20	18
24.2	14	10	16	13	84	15	12
24.3	23	19	61	43	7,081	68	43
25.0	42	49	30	24	91	37	34
26.0	21	17	32	26	1,015	106	116
Mean	166	216	171	141	8,234	256	248

Note: The quantity estimates in columns 3 through 8 are obtained by letting $\Delta P = 0$ in the appropriate least squares estimate of Eq. (IV.4).

site. When population centroids are used as origins, there is a large number of observations of low visit rates that are close to the regression line. The very few origin zones that have high visit rates and account for most of the total visits have relatively little influence on the regression line. The visit rates of the close origin zones are often estimated with large residuals. Aggregation results in a large number of good-fitting observations being combined into a few observations and, hence, reduces their influence on R^2.

Aggregation decreases the total number of observations and thereby increases the relative weight of the close origins in determining the regression line. The error in estimating these visit rates thereby decreases, and hence, so does the error in estimating total visits. The "solution" to the visit estimation problem is not increased aggregation; because aggregating from a 10-mile origin zone to a 20-mile origin zone actually decreases the reliability of predicting total visits (see Table 11, columns 4 and 5). Indeed, total visits could be predicted exactly if populations were of constant size across origins.[9]

Simulation estimates of each of these cases were again made using a double-log form. The results using a \$1 price increment and exogenous quantity demanded are presented in Table 12. The coefficients of determination in columns 2 and 5 are lower for a double-log model than for a semilog model when population centroids are aggregated into 10- or 20-miles zones. Furthermore, most of the surplus-per-day estimates are higher than one could reasonably expect. Overall, the aggregation process provides no credibility to the double-log form. This result also follows when we consider the double-log estimates of total use at a zero price. As seen in Table 11, aggregating population centroids into 10- or 20- mile origin zones improved the predictability of the model in terms of total use. However, the double-log model predicts total use with a larger error than a semilog model, regardless of the choice of origin zone.

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[9] The estimated residuals in predicting visit rates necessarily sum to zero, that is, $\Sigma(V_i - \hat{V}_i) = \Sigma(T_i/N_i - \hat{T}_i/N_i) = 0$. If the population of each origin is identical, $N\Sigma(T_i - \hat{T}_i) = 0$, visits ($T_i$) are also predicted exactly.

TABLE 12

DOUBLE-LOG VALUATION ESTIMATES USING 10-MILE AND 20-MILE ORIGIN ZONES

	10-Mile Origin Zones			20-Mile Origin Zones		
Recreation Centroid Number (1)	R^2 (2)	Consumers' Surplus (in $1000) (3)	Surplus per Day $ (4)	R^2 (5)	Consumers' Surplus (in $1000) (6)	Surplus per Day $ (7)
17.0	0.556	8,810	25.36	0.596	18,546	53.39
17.1	0.599	34,694	36.29	0.588	38,203	39.96
17.2	0.608	36,984	33.84	0.673	19,616	17.95
18.0	0.803	405	6.44	0.804	770	12.25
19.0	0.493	500	15.10	0.454	1,631	49.38
19.1	0.536	2,312	26.54	0.434	5,044	57.90
20.0	0.535	8,386	79.72	0.555	7,732	73.51
21.0	0.723	7,171	41.52	0.668	15,291	88.54
22.0	0.366	1,050	184.24	0.283	2,114	371.10
22.1	0.491	906	87.75	0.469	1,658	158.72
22.2	0.175	4,326	298.29	0.399	5,345	368.54
23.0	0.775	902	21.52	0.878	1,445	34.46
23.1	0.844	926	20.31	0.903	1,150	25.25
23.2	0.736	9,984	46.10	0.855	9,324	43.06
24.0	0.797	15	2.04	0.776	15	2.15
24.1	0.813	180	14.69	0.792	227	18.49
24.2	0.782	62	4.26	0.822	60	4.15
24.3	0.711	238	10.23	0.670	230	9.92
25.0	0.764	505	12.05	0.772	561	13.39
26.0	0.461	3,242	153.28	0.459	4,083	193.05
	0.627	6,080	55.93	0.643	6,653	81.76

3. Conclusions and Implications

This chapter presents travel-cost demand and value estimates for boating in 20 recreation centroids in Washington. The objective of the analysis is to determine the sensitivity of the results to three specification and computational assumptions, and thus to determine which assumptions are most appropriate.

A Monte Carlo analysis is used to examine questions that have not been resolved theoretically or empirically. We can find plausible results for at least one centroid in each of the tables; but by observing results for several sites, the deficiencies in various assumptions becomes apparent. The recreation literature has given only cursory attention to the issues considered here and many existing studies have been based on a single site.

The preference of most recreation analysts for a semilog specification of the first-stage demand function over a double log is confirmed by these results. In terms of goodness of fit, stability of results across sites, accuracy of predicting quantity demanded at a zero price, and a priori reasonableness of results, this specification is clearly superior to the double log.

Some recreation analysts, such as Common (1973), have used a double-log specification with satisfactory results. However, Common and others have tried alternative specifications for only one site. For some centroids, consumers' surplus estimates are insensitive to the specification, but this result is a special case that may be observed in a sample of one site. A particularly serious problem with the double-log specification is that on occasion it can produce totally unrealistic results. The source of this problem is unclear and cannot be determined from the regression estimates of the experience demand schedule. The cause of these occasional drastic results may, to a lesser extent, affect the apparently tenable results, hence these estimates should also be considered suspect.

This analysis of boating at 20 recreation centroids reflects a small sample of the 195 centroids and four recreation activities considered in the regional model. Recreation experience demand curves were estimated for each centroid and for each activity using both a double-log and semilog specification. The results are simliar to those reported here, with some estimates of consumers' surplus varying in sensitivity to the choice of functional form. About five percent of the results using a double-log specification are unreasonable.

The price-quantity observations depend upon the price increment used in Eq. (IV.5) and hence the area under these price-quantity observations, which is consumers' surplus, could also be affected by the size of the price increment. As seen by comparing Table 7 with Table 9, when a double-log form is used, total surplus and surplus per trip are sensitive to the size of this price increment. With a semilog specification, the results using a $0.25 price increment up to $1 and a $1 increment thereafter are virtually identical to those obtained using a $1 increment. The robustness of the semilog also suggests its superiority to the double-log form.

Quantity demanded at a zero price is usually estimated exogenously from site data, but it can also be estimated by setting $\Delta P = 0$ in Eq. (IV.5). The first estimate is based on observed (visit-rate) data and the second estimate is based on visit rates estimated from a regression equation. The two estimates are not identical, but one would hope that differences would be small and have a mean of zero. When origin zones are defined as population centroids, we observe wide differences between exogenous quantity estimates and quantity estimates obtained from Eq. (IV.5). One implication of this result is that if empirical estimates of Eq. (IV.5) were used to predict visits at a similar proposed site, a substantial error would be expected. Second, visit-rate schedules would yield inaccurate estimates of the effect of initiating an entrance fee on total use. As seen in Panel B of Figure 1, imposing a fee may lead to an increase in predicted visits.

When a semilog model is used, discrepancies in quantity estimates do not produce discrepancies in total consumers' surplus estimates (compare Table 7, column 3, with Table 8, column 4). This result implies that it may be feasible to estimate surplus at a proposed site, even when use cannot be estimated with reliability. Errors in estimating quantity demanded have a negligible effect on total surplus because surplus is estimated with Bode's Rule and not as the area under a regression equation. A regression estimate of a site-demand equation would be affected by the choice of quantity demanded. However, by using Bode's Rule to measure area under several points, the choice of one price-quantity point affects the area only in the neighborhood of that point. A second compelling reason for using Bode's Rule is to avoid the issue of the appropriate functional form of the site-demand curve.

The most disconcerting result of this chapter is that valuation estimates are sensitive to the definition of the origin zone. When each population centroid is construed as a separate zone, the explanatory power of the model is higher on the average than when centroids are aggregated into 10- or 20-mile zones. Furthermore, aggregating centroids results in a substantial loss of degrees of freedom, which with other things being equal, is undesirable, and in this case causes the results to become unstable. However, aggregating population centroids into origin zones improves the accuracy by which total use is predicted at a zero price.

Most travel-cost studies have been based on an aggregation of population centroids into concentric zones. The choice of a 10-mile versus 20-mile system of concentric circles affects the results, but there is a greater disparity between using zones and using population centroids as origins. A consequence of using each centroid as an origin is that a large proportion of the centroids account for a small proportion of the trips. In rough numbers, about 95 percent of the centroids account for only 10 to 15 percent of the trips. The experience demand curve is therefore influenced disproportionately by centroids that account for very few trips. There is some justification for using each population centroid as an origin zone and for aggregating centroids into concentric zones. The best choice is unclear. Because travel-cost valuation estimates are sensitive to the definition of the origin zone, this is an important topic for future work.

CHAPTER VII

EMPIRICAL ESTIMATES OF RECREATION BENEFITS OF IMPROVED WATER QUALITY IN THE PACIFIC NORTHWEST

This chapter presents empirical estimates of recreation benefits to be gained through improving water quality of degraded rivers and preserving water quality in selected lakes in the Pacific Northwest. The first section of this chapter presents a brief overview of the main determinants of recreation demand and valuation. The objective is to provide an intuitive explanation of the model and of the subsequent empirical estimates. The second section presents estimates of existing recreation benefits of eight selected lakes. The sample permits a contrast in benefits between urban and rural locations. Section 3 estimates recreation benefits on a county basis of improving water quality in all the degraded rivers in the Pacific Northwest.

1. Determinants of Recreation Value and Use

Travel-cost analyses have documented that recreation behavior can be explained quite well by four independent variables: population size, travel cost to the site, site characteristics, and the availability of substitute sites. The population centers that send recreators to a specific site are obviously a critical determinant of potential demand. The actual number of lake users is influenced more by the potential number of users than perhaps by any other variable. However, populations of equal size do not necessarily produce the same number of recreation trips. Demographic characteristics such as household size and income influence participation rates. In the Northwest, these variables influence the number of trips per household [Eq. (III.8)], but population size is the main determinant of days spent recreating.

The number of users of a lake is influenced significantly by the distances to the population origins. Recreators typically are adverse to travel and therefore, other things being equal, the greater the required travel distance, the fewer will be the users of a lake. The increase in travel costs, particularly gasoline, in the last several years could increase the demand for lakes closer to population centers at the expense of more distant sites. In addition to the aversion to travel, distance also tends to diminish use because the greater the distance from origins to the recreation site, the greater the probability of preferred substitutes closer to the population origins.

The use and value of a recreation site depends on the existence of competitive or substitute recreation sites. If a site has one or more close substitutes, the value-per-unit day will be less than if the site has no close substitutes. A site preferred over its competitors will have a high use even though a low value per use day. A site that is generally less preferred than its competitors will have low use and low value per day. Furthermore, substitute sites may be located in the same proximity, but this is certainly not necessary. Figure 9 depicts two population centers that, for illustrative purposes, are assumed to be located on the same straight road. In this illustration, there are four recreation sites that are assumed to be identical except for location. Most, if not all, recreators from population center 1 will visit site A. Site B is not a close substitute for site A because of greater travel costs. Recreators from population center 2 will recreate at sites C and D, which are close substitutes because of their identical travel distances, even

FIGURE 9

THE EFFECT OF SUBSTITUTE SITES ON DEMAND AND VALUE

Distance (in miles)		← 5 →		← 25 →		← 10 →		← 30 →		← 30 →	
Center (Population, Recreation)	Site A		Pop. 1		Site B		Site C		Pop. 2		Site D
Trips from Origin			100						100		
Trips to Destination	95				10		48				47
Value per Day	$5				$0.50		$1				$1

though they are 60 miles apart. In contrast, sites B and C are not close substitutes even though they are only 10 miles apart.

In this illustration, site A receives the greatest use and has the greatest value-per-user day. Demand is relatively price inelastic because the site has no close substitute. Sites C and D receive significant·use but have low values per user day; the demand for each of these sites is very price elastic because each site is a close substitute for the other. Site B is closer to a population center than is either site C or site D, however B is dominated by other sites preferred by both population centers. Thus, site B receives only minimal use and has a low value per day. By implication it may not be cost-effective to improve recreation opportunities at site B, because the presence of a preferred substitute discourages use at B.

This example illustrates the importance of considering substitute sites when selecting lakes for restoration. To emphasize this point, consider the conditions in Figure 9, and assume that water quality is uniformly poor at all sites. Now, which lakes would be cost-effective to restore? The highest priority in items of recreation benefits is likely to be site A. This site has the greatest potential demand because it is located near a population center and has no close substitutes. Sites C or D are also a high priority, but it would probably be cost-effective to restore only one of these sites. If one of these two lakes were restored, use and value per day would be high at that site. If both were restored, use would be divided between the lakes and value per day would be low. If site A and either C or D were restored, restoring lake B would probably not be cost-effective because of the availability of preferred substitutes.

The fourth major determinant of recreation demand and value is the site characteristics including lake size, aesthetics, recreation facilities, and water quality. These characteristics, in combination, determine the ability of a site to attract recreators from various origins. Defining, weighing, and measuring these characteristics has proven a major challenge to researchers analyzing recreation demand and value. Recreation facility data serve as a proxy for these characteristics because these data are available on a county basis across the entire region.

If a lake is to be used for public recreation, it must have public access. Also, there must be facilities appropriate to the various recreation activities. For instance, a swimming beach is important for swimming, boat ramps are necessary for boating, and camping facilities are required for camping. No particular facilities are required for fishing, but the appropriate site characteristic is probably the anticipated catch.

Water quality is one characteristic of a site and like other aesthetic qualities, it is subjective and difficult to define and to measure. Estimating the response of recreation use and value to changes in water quality is also difficult because this response varies widely across sites and depends on the initial value of the other determinants of recreation demand. To illustrate, assume that water quality of each site in Figure 9 is identical and can be described as moderate to good. Under these assumptions, water quality improvement would encourage additional demand at site C or site B, but not both, because these sites are close substitutes. Improving water quality at site A will not encourage additional use because site A is already heavily utilized and cannot attract recreationists from substitute sites.

Water-quality improvement efforts may be directed toward maintaining existing good water as well as improving the quality of degraded water. Maintaining existing value and use may be the goal of preventive water-quality programs if in the absence of such action, water would become degraded and use would decline. Referring again to Figure 9, water-quality protection would not appear to be justified at site B, because of negligible demand. This result depends critically on two assumptions: (1) that water quality is uniformly good at other sites; and (2) there exists a site that is preferred to site B. However, if water quality were uniformly poor, improving site B would encourage a significant increase in use from both population centers 1 and 2. Preventive actions may not be justified at C or D because if either site became unusable, demand would merely shift to the other site, which is a close substitute. However, if both sites were threatened, maintaining quality at both sites or at least at one site would induce large benefits. The site with the greatest potential preservation value is clearly site A. The uniqueness of site A is its high existing value and use, which are determined by its nearness to a population center and the absence of close substitutes. This point can be generalized. The greater the current use of a site and the fewer its substitutes, the stronger is the justification for preserving water quality at that site. Even with the stringent assumption that water quality is uniformly good to moderate, the basic conclusion is that those sites that offer the greatest potential increase in use and value are not necessarily the sites where preserving the existing level of water quality is cost-effective.

2. Demand and Valuation Estimates for Selected Lakes

A sample of eight lakes was selected to indicate the recreation value of preserving good water quality at urban versus rural locations. The demand and valuation estimates of these lakes are explained in terms of the determinants of demand, as described in the previous section. Although three of the lakes considered here are affected by the EPA's Clean Lakes Program (Liberty, Medical and Fernridge Reservoir), demand and benefits are estimated under the assumption that existing water quality does not discourage use.

A summary of the demand and valuation estimates is presented in Table 13. Column 3 contains data on facilities for the corresponding activity. This variable is a proxy for the characteristics of a recreation site and should be positively correlated with demand and value of the site. The accessibility of a recreation site is measured as the weighted sum of recreation activity days emanating from each population center, as defined by Eq. (III.5). The weights are the probability that a person will travel the distance from the respective origin to the corresponding recreation site. Accessibility reflects the joint influence of population size and distance. The closer a site to population centers and the greater the number of recreation trips produced by these centers, the larger the accessibility number. The level of facilities and accessibility of a site jointly determine total visitor-days by activity for the site.

The first two lakes shown in Table 13, Lake Washington and Lake Sammamish, are large urban lakes with numerous recreation facilities. These lakes are

TABLE 13

ANNUAL RECREATION DEMAND AND VALUE OF SELECTED LAKES IN THE PACIFIC NORTHWEST (1979 DOLLARS)

Recreation Centroid Number (1)	Lake and County (2)	Activity (3)	Facility* (4)	Access.** (5)	Annual Visitor Days (in 1000) (6)	Recreation Value (in $1000) (7)	Value per Trip $ (8)
17.1	Lake Sammamish	Swimming	3,000	2,755,403	4,069	18,446	4.54
	King County	Camping	150	2,633,395	2,123	8,038	3.79
		Fishing	220	2,003,932	1,745	5,085	2.91
		Boating	12	1,596,838	4,424	30,968	7.00
		Total			12,361	62,557	5.06
17.2	Lake Washington	Swimming	7,000	2,883,916	4,837	21,880	4.52
	King County	Camping	1	2,511,231	153	603	3.94
		Fishing	100	2,199,562	1,791	4,589	2.56
		Boating	39	1,656,586	9,616	66,773	6.94
		Total			16,397	93,845	5.72
10.0	Twin Lakes	Swimming	400	201,214	100	596	5.97
	Ferry County	Camping	117	507,609	170	905	5.33
		Fishing	525	117,229	95	535	5.64
		Boating	4	223,566	41	342	8.33
		Total			406	2,378	5.86
24.0	Perrygin Lake	Swimming	275	90,521	46	393	8.58
	Okanogan County	Camping	120	333,922	93	729	7.87
		Fishing	800	45,169	47	402	8.54
		Boating	4	139,078	18	194	10.76
		Total			204	1,718	8.42
48.1	Priest Lake	Swimming	6,750	218,585	157	818	5.22
	King County	Camping	1,265	550,561	640	2,743	4.29
		Fishing	310	143,338	112	485	4.31
		Boating	26	240,518	137	1,005	7.35
		Total			1,046	5,051	4.83
32.0	Medical Lake	Swimming	150	989,653	747	3,114	4.17
	Spokane County	Camping	4	1,357,021	134	551	4.10
		Fishing	61	650,469	509	1,806	3.55
		Boating	5	705,431	563	3,594	6.38
		Total			1,953	9,065	4.64
32.2	Liberty Lake	Swimming	100	1,232,264	844	3,970	4.70
	Spokane County	Camping	25	1,637,891	441	1,829	4.15
		Fishing	50	851,309	639	2,387	3.79
		Boating	1	880,733	303	2,114	6.97
		Total			2,218	10,300	4.64
103.2	Fernridge Reservoir	Swimming	6,608	309,616	383	2,236	5.83
	Lane County	Camping	200	777,142	446	2,147	4.81
		Fishing	75	335,729	311	1,117	3.59
		Boating	33	254,786	193	1,741	9.01
		Total			1,333	7,241	5.43

*The facilities for the activities are: linear beach feet, camping units, acceptable river and shoreline miles, and number of boat ramps.

**Access. means accessibility and is a positive function of the nearness to population centers and the size of these centers. See Eq. (III.13), p. 52.

located in the Seattle Standard Metropolitan Statistical Area (SMSA), the largest concentration of people in the Northwest. The annual value of the water-based recreation activity on these lakes is estimated to be $93.8 and $62.6 million, respectively, making them the most valuable recreation lakes in the region.[1] These high annual values reflect the combination of short travel distance, large population centers, and numerous recreation facilities, particularly for swimming and boating.

Of the other six lakes in Table 13, three are urban and three are rural. Twin Lakes, Perrygin Lake, and Priest Lake are each more than 50 miles from a major population center. In contrast, Medical Lake and Liberty Lake are within 20 miles of Spokane, Washington (SMSA population is 304,058), and Fernridge Reservoir is about 12 miles from Eugene-Springfield, Oregon (SMSA population, 271,130). Fernridge Reservoir is used more extensively than the other lakes and has a corresponding higher value. The use and value of the other five lakes is similar.

The significance of an urban versus rural location is easily appreciated by comparing swimming estimates of two urban lakes, Medical and Liberty, with those of the two rural lakes, Perrygin and Twin Lakes. Medical and Liberty have only 150 and 100 linear beach feet, respectively, whereas Perrygin and Twin Lakes have 275 and 400 linear swimming beach feet. The urban lakes are very accessible (see column 5, Table 13), and the two rural lakes relatively inaccesible. Thus, even though the two urban lakes offer fewer swimming opportunities (measured by linear beach feet), they receive more use and have a corresponding higher value than the rural lakes.

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[1] Crater Lake, in Oregon, attracts visitors nationwide and even from abroad, but not for recreation reasons, because fishing, boating, and swimming are prohibited. Crater Lake certainly has a high value, but it is not included in this study.

Although benefit estimates are presented here for only eight lakes in the Northwest, some general conclusions are suggested. First, those lakes that offer extensive recreation opportunities and are located near large population centers will receive extensive recreation use, and this use will have a high total value. The demand and valuation estimates for Lake Washington and Lake Sammamish reflect their proximity to large population centers and their abundant recreation facilities. The estimate of annual recreation value of $7.2 million for Fernridge Reservoir is significantly less than the estimates of the above two lakes. However, this reservoir is smaller, located further from a population center, and the population center has fewer people. The counterpart to the principle stated above is that lakes without recreation facilities that are located a significant distance from major population centers will not be heavily used and will have corresponding low recreation values. The two lakes farthest from population centers, Twin Lakes and Perrygin Lake, have the lowest total recreation value. Two of the lakes (Newman and Liberty) are not particularly attractive in terms of their recreation facilities, but are located near Spokane, Washington, which is a large urban center. The other three lakes are located in rural areas but offer appealing site characteristics that attract recreators from several miles.

3. Benefits of Improving Water Quality in Streams

This section presents estimates of recreation benefits that would accrue if the degraded rivers and streams in the Pacific Northwest were made fishable and swimmable.

In the Northwest, camping, fishing, swimming, and boating generally occur where water quality is high and appropriate facilities are available. In those areas where water is degraded, recreation facilities have not been provided and recreation does not occur. Water quality and recreation facilities are complements and for purposes of this study are assumed to be perfect complements. Improved water quality will not stimulate recreational use unless there is a corresponding improvement of related facilities such as swimming beaches, boat ramps, or campsites. Recreation facilities are not viewed as a true causal variable, but as a statistical proxy for a large number of nonquantifiable variables that in combination determine the attractiveness of a recreation site.[2] Fishing is the exception as no facilities are required for fishing. The quality variable that is assumed comparable to recreation facilities is the number of fishable river miles and lake shoreline miles. The exogenous variables that drive the model are: linear swimming beach feet, number of boat ramps, camping units, and fishable river and shoreline miles. An increase in any of these variables will increase demand and consumers' surplus, where it is implicit that water quality is "acceptable" for recreational purposes. Similarly, an improvement in water quality must be accompanied by an increase in one or more of the above variables if use and benefits are to be affected.

The Region X (Seattle) office of the U.S. Environmental Protection Agency (EPA) has published a series of water-quality assessment reports covering each major river basin in the Pacific Northwest. Water quality was assessed for each major stream and for various reaches on these streams using both recreational and biological criteria. Water quality is indicated for recreation in general and is not estimated for each of the four activities analyzed in this paper. Water quality was not measured on a continuous scale, rather it was judged to be acceptable, objectionable, or not acceptable. An acceptable stream is one meeting the 1983 Federal water-quality goals of fishable and swimmable streams. Although standard water quality parameters, for example, turbidity, were used in assessing water quality, professional judgment was also a factor. The objectionable and not acceptable river stretches were noted on U.S. Geological Survey base maps for each of the three states. A planimeter was then used to tabulate degraded and acceptable river miles on a county basis. The resulting estimates of acceptable and degraded river miles serve as the basic water-quality inventory data for this study.

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[2] A report by the Institute of Transportation and Traffic Engineering (1971, ch. 7) includes an effort to construct a recreation attractiveness index for camping by defining 28 characteristics of campgrounds and applying factor analysis to select the most important factors. The factors that were selected accounted for 41.5% of the variance in the observed data. It is not feasible to apply a similar approach in this study because much of the required data do not exist, and the data that are available are of poor quality. The large scale effort that would be required to complete the analysis is not justified by the improvement in the results.

Given the assumption that water quality and facilities are perfect complements, it is feasible to estimate water-quality benefits by estimating the benefits of increasing facilities on degraded rivers. The number and type of facilities that could be constructed if water quality were improved was estimated by state recreation planners. The assistance of these planners was sought because of their first-hand knowledge of the recreational potential of the various areas in their respective states. The recreation planners were shown a U.S. Geological Survey base map (scale 1:500,000) of their state with the degraded rivers marked and asked the following question for each degraded river segment. "If water quality were improved, would this area be conducive to any of the four activities being considered here?" When the answers were affirmative, the next question asked was, "How many facilities by type could reasonably be constructed along the degraded river?" Although this method of estimating the potential increment in facilities certainly lacks scientific rigor, all recreation facilities data were obtained from the state recreation officials, whose responsibility is to recommend the development of state recreation areas.

Based on these interviews with the state recreation planners, estimates were made of the potential increment in recreation facilities (boat ramps, swimming beach feet, and campsites) that could be constructed at each recreation centroid if the degraded water were improved. Estimates of observed and potential facilities by activity and recreation centroid are presented in Appendix A, Table A.5. The incremental variable that enters the model for fishing is degraded river miles by centroid. This variable was estimated with EPA data and did not require the assistance of the recreation planners. The estimated increment in facilities should be interpreted as the maximum potential change and not as an estimate of what would occur if water quality were improved. Recreation benefit estimates therefore represent an upper bound that can be attained only by cooperation with those responsible for planning and developing recreation sites.

Recreation demand and value was estimated for each of four activities and for each of the 195 selected recreation centroids in the Northwest on the basis of existing water quality and level of facilities (see Table A.4). Demand and value were again estimated assuming that all degraded water was made fishable and swimmable and the assumed facilities were constructed. The increments in benefits for each activity are presented on a county basis in Table 14. The 16 recreation centroids in western Montana are not included in this analysis.

The main result from Table 14 is that substantial incremental benefits, (for example, over one million dollars) are concentrated in a few counties and that most counties show much lower benefits. As expected, the counties with the largest potential benefits are those accessible to the largest populations. The Washington counties with the largest populations in order are King, Pierce, and

TABLE 14

ANNUAL RECREATION BENEFITS OF IMPROVED WATER QUALITY IN STREAMS BY ACTIVITY AND BY COUNTY FOR WASHINGTON, OREGON, AND IDAHO

	Washington				
County	Swimming $	Camping $	Fishing $	Boating $	Total Recreation Benefits $
Adams	0	0	0	0	0
Asotin	0	222,016	2,598	30,327	254,941
Benton	20,471	0	14,071	0	34,542
Chellan	0	0	0	0	0
Clallum	0	0	0	0	0
Clark	0	0	0	0	0
Columbia	0	0	0	0	0
Cowlitz	0	0	0	25,015	27,015
Douglas	65,794	414,745	7,207	24,616	512,362
Ferry		138,208	8,101	0	146,309
Franklin	0	0	0	0	0
Garfield	0	0	0	0	0
Grant	0	194,394	1,830	0	196,224
Grays Harbor	26,692	0	0	0	26,692
Island	0	0	0	0	0
Jefferson	0	0	0	0	0
King	0	2,358,906	14,373	693,112	3,066,391
Kitsap	0	0	0	0	0
Kittitas	0	204,163	0	0	204,163
Klickitat	0	0	0	0	0
Lewis	0	0	0	154,300	154,300
Lincoln	0	0	0	0	0
Mason	0	0	0	0	0
Okanogan	0	127,453	0	136,550	264,003
Pacific	0	0	0	0	0
Pend Oreille	0	0	0	0	0
Pierce	0	1,347,167	165,450	1,050,138	2,562,755
San Juan	0	0	0	0	0
Skagit	467,354	0	0	0	467,354
Skamania	0	0	0	0	0
Snohomish	0	0	0	0	0
Spokane	637,896	1,051,884	0	870,667	2,560,447
Stevens	0	0	36,335	0	36,335
Thurston	251,302	0	26,445	5,360,468	5,638,215
Wahkiakum	0	0	0	0	0
Walla Walla	0	0	7,960	0	7,960
Whatcom	0	0	0	0	0
Whitman	0	0	0	0	0
Yakima	0	453,419	11,993	1,013,475	1,478,887
Total Incremental Benefits	1,469,509	6,512,335	296,363	9,360,668	17,638,895

TABLE 14 (continued)

	Idaho				
County	Swimming $	Camping $	Fishing $	Boating $	Total Recreation Benefits $
Ada	0	0	0	0	0
Adams	0	0	0	652	652
Bannock	131,356	0	0	0	131,356
Bear Lake	0	0	0	925	925
Benewah	0	0	0	0	0
Bingham	0	0	37,707	5,993	43,700
Blaine	3,808	0	88,530	0	92,338
Boise	0	0	0	0	0
Bonner	0	0	0	0	0
Bonneville	7,705	0	15,237	0	22,942
Boundary	0	0	0	0	0
Butte	34,910	0	34,481	0	69,391
Camas	0	0	0	0	0
Canyon	29,048	0	12,798	37,532	79,378
Caribou	21,400	0	0	0	21,400
Cassia	139,965	0	19,925	8,706	168,596
Clark	22,589	0	2,390	0	24,979
Clearwater	12,091	73,216	0	17,922	103,229
Custer	2,988	17,311	106,986	5,267	132,552
Elmore	0	0	0	0	0
Franklin	2,662	0	4,184	2,435	9,281
Fremont	20,775	0	5,506	697	26,978
Gem	0	0	0	0	0
Gooding	129,722	0	0	4,583	134,305
Idaho	0	0	0	0	0
Jefferson	22,572	0	164,082	0	186,654
Jerome	0	0	0	0	0
Kootenai	0	0	0	0	0
Latah	0	0	0	0	0
Lemhi	618	1,300	0	653	2,571
Lewis	0	0	0	0	0
Lincoln	52,829	0	40,659	0	93,488
Madison	18,864	0	57,764	0	76,628
Minidoka	0	0	0	0	0
Nez Perce	0	0	0	0	0
Oneida	64,168	0	21,117	2,956	88,241
Owyhee	0	0	10,828	0	10,828
Payette	0	0	0	0	0
Power	0	0	0	0	0
Shoshone	185,954	67,601	0	45,743	299,298
Teton	40,826	0	13,092	2,107	56,025
Twin Falls	86,172	0	43,814	3,740	133,726
Valley	0	0	0	11,954	11,954
Washington	5,647	0	149	0	5,796
Total Incremental Benefits	$1,036,669	$159,428	$679,249	$151,865	$2,027,211

TABLE 14 (continued)

	Oregon				
County	Swimming $	Camping $	Fishing $	Boating $	Total Recreation Benefits $
Baker	0	0	0	0	0
Benton	1,597,504	0	42,056	0	1,639,560
Clackamas	0	0	0	97,130	97,130
Clatsop	0	0	0	0	0
Columbia	0	0	0	0	0
Coos	0	0	21,716	0	21,716
Crook	2,858	179,842	0	12,601	195,301
Curry	0	0	0	0	0
Deschutes	157,796	83,710	11,016	4,506	257,028
Douglas	65,229	485,883	110,447	40,153	701,712
Gilliam	0	0	0	0	0
Grant	0	0	0	0	0
Harney	0	6,877	1,734	0	8,611
Hood River	0	0	47,798	0	47,798
Jackson	0	0	0	0	0
Jefferson	0	0	0	0	0
Josephine	0	0	0	0	0
Klamath	0	1,099	0	0	1,099
Lake	0	0	0	0	0
Lane	0	711,274	87,815	0	799,089
Lincoln	0	62,287	64,894	0	127,181
Linn	875	0	0	10,720	11,595
Malheur	0	0	0	0	0
Marion	0	0	0	0	0
Morrow	0	0	0	0	0
Multnomah	0	0	0	0	0
Polk	112,649	0	30,448	192,895	335,992
Sherman	0	0	0	0	0
Tillamook	0	0	0	0	0
Umatilla	0	0	0	0	0
Union	0	0	0	8,325	8,325
Wallowa	0	0	0	0	0
Wasco	0	0	0	0	0
Washington	56,586	62,669	4,515	358,683	482,453
Wheeler	0	0	0	0	0
Yamhill	1,353,222	766,698	26,336	181,793	2,328,049
Total Incremental Benefits	$3,346,719	$2,360,339	$448,775	$906,806	$7,062,639
Total Regional Incremental Benefits	$5,852,897	$9,032,122	$1,424,387	$10,419,339	$26,728,745

Spokane, and these counties show corresponding large recreation benefits. The most populated counties in Idaho and Oregon are Ada and Multnomah. Each county has no water-quality benefits, but neither county has a water-quality problem.

Fifty-eight of the total 119 counties indicate zero total potential recreation benefits and several more show no benefits for certain activities. Of these 58 counties, 33 have no officially degraded water and therefore have no potential benefits. An additional 16 counties that have a water-quality problem were judged to be not conducive to recreation even if water quality were improved. These counties are typically rural where agriculture is the economic base.

Zero or low benefits also occur for those counties that are significant distances from population centers. Even if water quality were improved and facilities added, demand would not increase significantly in those areas that are inaccessible. Preservation values are significantly larger than potential incremental benefits for each activity and for each state. This result owes to the abundance of existing accessible recreation opportunities. The attractions model, Eq. (III-6')-(III-9') (Table 2), provides empirical evidence that the response of attractions to facilities diminishes as the level of facilities increases. The results in Table 14 cannot be extrapolated to other regions that may have different population densities, existing recreation opportunities, and water-quality problems.

4. Conclusions

A model has been presented that can be used to estimate recreation benefits for four water-based activities within a three and one-half state region. Benefits can be estimated for any single site or for several sites simultaneously. Benefits also can be estimated for preserving existing water quality as well as improving degraded water. The main conclusion is that, with respect to the three Northwestern states, the largest potential recreation benefits exist near the population centers. In contrast, improving water quality in sparsely populated agricultural areas will probably not stimulate a substantial increase in recreation demand.

The benefit estimates in Table 14 may appear discouraging in terms of the economic viability of meeting the national goal of "fishable and swimmable" water. Indeed, improving water quality in some agricultural areas may not be cost-effective. However, potential recreation benefits at several sites exceeds $1 million per year. Also, certain nonrecreation benefits such as property values, aesthetic values, option demand, and perhaps drinking water and health benefits are likely to display the same geographic pattern as recreation benefits. That is, these potential benefits may also correlate with population densities. A more comprehensive analysis of benefits, focusing particularly on those listed above could conclude that total water-quality benefits are substantially larger than those presented in Table 14. For example, in a valuation study of the Flathead Lake and River system in western Montana using this model, recreation values are estimated to be $6.3 million per year (Sutherland 1982d). However, in the same study, nonuser values (option, existence, and bequest) are estimated to be $97.3 million per year for the same region.

APPENDIX A

DATA TABLES

TABLE A.1

POPULATION CENTROIDS, POPULATION, AND COUNTIES

Population Centroid Number	Washington		
	County	Population Centroid	Population
1.0	Adams	Othello	13,322
2.0	Asotin	Clarkston	16,822
3.0	Benton	Kennewick	42,383
3.1	Benton	Richland	66,291
4.0	Chellan	Wenatchee	44,980
5.0	Clallum	Port Angeles	51,224
6.0	Clark	Vancouver	192,060
7.0	Columbia	Dayton	4,098
8.0	Cowlitz	Kelso	79,489
9.0	Douglas	Waterville	22,156
10.0	Ferry	Republic	5,748
11.0	Franklin	Pasco	34,613
12.0	Garfield	Pomeroy	2,483
13.0	Grant	Moses Lake	48,040
14.0	Grays Harbor	Aberdeen	66,356
15.0	Island	Oak Harbor	44,016
16.0	Jefferson	Port Townsend	15,903
17.0	King	Seattle	998,909
17.1	King	Auburn	50,568
17.2	King	Kent	37,925
17.3	King	Renton	38,397
17.4	King	Bellevue	139,061
18.0	Kitsap	Port Orchard	145,990
19.0	Kittitas	Elensburg	24,866
20.0	Klickitat	Goldendale	15,879
21.0	Lewis	Chahalis	55,450
22.0	Lincoln	Davenport	9,597
23.0	Mason	Shelton	30,896
24.0	Okanogan	Omak	30,654
25.0	Pacific	Raymond	17,234
26.0	Pend Oreille	Newport	8,561
27.0	Pierce	Tacoma	482,692
28.0	San Juan	Friday Harbor	7,793
29.0	Skagit	Mt. Vernon	63,184
30.0	Skamania	Stevenson	7,914
31.0	Snohomish	Everett	221,739
31.1	Snohomish	Edmonds	114,214
32.0	Spokane	Spokane	341,058
33.0	Stevens	Colville	29,008
34.0	Thurston	Olympia	124,249
35.0	Wahkiakum	Cathlamet	3,824
36.0	Walla Walla	Walla Walla	47,267
37.0	Whatcom	Bellingham	105,198
38.0	Whitman	Pullman	40,321
39.0	Yakima	Yakima	170,767

(continued)

TABLE A.1 (continued)

Population Centroid Number	Idaho		
	County	Population Centroid	Population
40.0	Ada	Boise	172,843
41.0	Adams	Council	3,347
42.0	Bannock	Pocatello	65,448
43.0	Bear Lake	Montpelier	6,946
44.0	Benewah	St. Maries	8,295
45.0	Bingham	Blackfoot	36,473
46.0	Blaine	Ketchum	9,825
47.0	Boise	Horseshoe Bend	2,998
48.0	Bonner	Sandpoint	24,155
49.0	Bonneville	Idaho Fall	65,971
50.0	Boundary	Bonners Ferry	7,302
51.0	Butte	Arco	3,351
52.0	Camas	Fairfield	809
53.0	Canyon	Namp	83,601
54.0	Caribou	Soda Springs	8,689
55.0	Cassia	Burley	19,476
56.0	Clark	Dubois	798
57.0	Clearwater	Orofino	10,383
58.0	Custer	Chalis	3,392
59.0	Elmore	Mountain Home	21,502
60.0	Franklin	Preston	8,892
61.0	Fremont	St. Anthony	10,806
62.0	Gem	Emmet	11,967
63.0	Gooding	Gooding	11,845
64.0	Idaho	Grangeville	14,724
65.0	Jefferson	Rigby	15,316
66.0	Jerome	Jerome	14,804
67.0	Kootenai	Couer d'Alene	59,914
68.0	Latah	Moscow	28,667
69.0	Lemhi	Salmon	7,444
70.0	Lewis	Kamiah	4,084
71.0	Lincoln	Shoshone	3,439
72.0	Madison	Rexburg	19,502
73.0	Minidoka	Rupert	19,693
74.0	Nez Perce	Lewiston	33,232
75.0	Oneida	Malad City	3,233
76.0	Owyhee	Homedale	8,239
77.0	Payette	Payette	15,827
78.0	Power	American Falls	6,879
79.0	Shoshone	Kellogg	19,234
80.0	Teton	Driggs	2,907
81.0	Twin Falls	Twin Falls	52,869
82.0	Valley	McCall	5,633
83.0	Washington	Weiser	8,815

(continued)

TABLE A.1 (continued)

Population Centroid Number	Oregon		
	County	Population Centroid	Population
84.0	Baker	Baker	16,127
85.0	Benton	Corvallis	68,078
86.0	Clackamas	Lake Oswego	193,085
86.1	Clackamas	Oregon City	44,120
87.0	Clatsop	Astoria	32,467
88.0	Columbia	St. Helens	35,709
89.0	Coos	Coquille	15,453
89.1	Coos	Coos Bay	48,477
90.0	Crook	Prineville	13,097
91.0	Curry	Gold Beach	13,186
91.1	Curry	Brookings	3,749
92.0	Deschutes	Bend	62,117
93.0	Douglas	Roseburg	93,100
94.0	Gilliam	Condon	2,061
95.0	Grant	Canyon	8,216
96.0	Harney	Burns	8,306
97.0	Hood River	Hood River	15,810
98.0	Jackson	Medford	115,279
98.1	Jackson	Ashland	16,156
99.0	Jefferson	Madras	11,556
100.0	Josephine	Grants Pass	52,937
101.0	Klamath	Klamath Falls	59,048
102.0	Lake	Lakeview	7,523
103.0	Lane	Eugene	271,130
104.0	Lincoln	Newport	15,185
104.1	Lincoln	Lincoln City	20,129
105.0	Linn	Albany	87,743
106.0	Malheur	Vale	18,727
106.1	Malheur	Ontario	8,164
107.0	Marion	Salem	181,964
107.1	Marion	Woodburn	22,490
108.0	Morrow	Heppner	7,525
109.0	Multnomah	Portland	559,058
110.0	Polk	Dallas	45,201
111.0	Sherman	Moro	2,177
112.0	Tillamook	Tillamook	21,170
113.0	Umatilla	Pendleton	58,816
114.0	Union	La Grande	23,935
115.0	Wallowa	Enterprise	7,269
116.0	Wasco	The Dalles	21,711
117.0	Washington	Hillsboro	245,684
118.0	Wheeler	Fossil	1,511
119.0	Yamhill	McMinnville	55,230

(continued)

TABLE A.1 (continued)

Population Centroid Number	Western Montana		
	County	Population Centroid	Population
120.0	Cascade	Great Falls	89,367
121.0	Flathead	Kalispell	41,462
122.0	Gallatin	Bozeman	67,414
123.0	Flathead	Whitefish	10,000
124.0	Lake	Polson	19,098
125.0	Lewis and Clark	Helena	49,992
126.0	Lincoln	Libby	17,731
127.0	Missoula	Missoula	79,091
128.0	Silver Bow	Butte	95,067
	External Zones		
129.0	Eastern Montana	Billings	159,117
130.0	British Columbia	Vancouver	2,206,608
131.0	British Columbia	Cranbrook	200,000
132.0	Alberta	Calgary	1,838,037
133.0	Wyoming	---	470,816
134.0	Utah	---	1,461,037
135.0	Nevada	---	799,184
136.0	California	---	23,668,562
137.0	Alaska	---	330,000
138.0	Eastern Canada	---	18,687,959
139.0	North Central	---	50,571,000
140.0	Northeast	---	61,880,000
141.0	Southeast	---	41,487,000
143.0	South Central	---	31,440,000

Notes: The population estimates for western Montana counties include neighboring counties, for which no population centroid is used. For instance, Missoula includes Mineral and Granite; Butte includes Silver Bow, Deer Lodge, and Powell; and Jefferson includes Beaverhead and Ravalli counties. Population estimates for all United States counties and states are preliminary estimates from the 1980 census, U.S. Department of Commerce, Bureau of Census, 1980 Census of Population and Housing (by state), 1981.

TABLE A.2

RECREATION CENTROIDS BY NAME, COUNTY, AND CENTROID NUMBER

Recreation Centroid Number	County	Recreation Centroid
1.0	Adams	Northwest corner
2.0	Asotin	Field Springs State Park
3.0	Benton	Crow Butte State Park
4.0	Chelan	Lake Wenatchee State Park
4.1	Chelan	Lake Chelan State Park
5.0	Clallum	Bogachiel State Park
5.1	Clallum	Neah Bay State Park
5.2	Clallum	Dungeness State Park
6.0	Clark	Battleground State Park
7.0	Columbia	Lewis and Clark State Park
8.0	Cowlitz	Merwin Reservoir
8.1	Cowlitz	Seaquest State Park
9.0	Douglas	Chief Joseph
10.0	Ferry	Twin Lakes
11.0	Franklin	Lyons Ferry State Park
12.0	Garfield	Pataha Creek
13.0	Grant	Potholes State Park
13.1	Grant	Sun Lakes State Park
13.2	Grant	Steamboat State Park
14.0	Grays Harbor	Bay City
14.1	Grays Harbor	Ocean City State Park
14.2	Grays Harbor	Lake Quinalt
15.0	Island	Camano Island State Park
15.1	Island	Deception Pass State Park
16.0	Jefferson	Kalaloch
16.1	Jefferson	Olympic National Park
16.2	Jefferson	Dosewallips State Park
17.0	King	Snoqualm
17.1	King	Lake Sammamish
17.2	King	Lake Washington
18.0	Kitsap	Horshoe Lake
19.0	Kittitas	Wawapum State Park
19.1	Kittitas	Lake Kachess
20.0	Klickitat	Horsethief Lake State Park
21.0	Lewis	Ike Kinswa State Park
22.0	Lincoln	Grand Coulee Dam
22.1	Lincoln	Fort Spokane
22.2	Lincoln	Sprague Lake
23.0	Mason	Lake Cushman
23.1	Mason	Belfair
23.2	Mason	Dash Point State Park
24.0	Okanogan	Pearrygin Lake State Park
24.1	Okanogan	Conconolly State Park

(continued)

TABLE A.2 (continued)

Recreation Centroid Number	County	Recreation Centroid
24.2	Okanogan	Alta Lake State Park
24.3	Okanogan	Osoyoos Lake State Park
25.0	Pacific	Fort Canby
26.0	Pend Oreille	Skookum Lakes
26.1	Pend Oreille	Crawfield
27.0	Pierce	Alder Lake
27.1	Pierce	Mount Ranier National Park
27.2	Pierce	Tolomerie State Park
28.0	San Juan	Morgan State Park
29.0	Skagit	Bayview State Park
29.1	Skagit	Rockport State Park
30.0	Skamania	Spirit Lake
30.0	Skamania	Beacon Rock State Park
31.0	Snohomish	Wenberg State Park
31.1	Snohomish	Skyomish Park
32.0	Spokane	Four Lakes
32.1	Spokane	Newman Lake
32.2	Spokane	Liberty Lake
32.3	Spokane	Lake Williams
32.4	Spokane	Long Lake
33.0	Stevens	Waihs Lake
33.1	Stevens	Loon Lakes
33.2	Stevens	Kettle Falls Recreation Area
34.0	Thurston	Miller State Park
35.0	Wahkiakum	Cathlamet
36.0	Walla Walla	Columbia State Park
37.0	Whatcom	Birch Bay State Park
37.1	Whatcom	Mount Baker
37.2	Whatcom	Colonial Bay
37.3	Whatcom	Ross Lake
38.0	Whitman	Ross Lake
39.0	Yakima	Rimrock Lake
40.0	Ada	Lucky Peak Reservoir
41.0	Adams	Oxbow Dam
42.0	Bannock	Lava Hot Springs
43.0	Bear Lake	Bear Lake Recreation Area
44.0	Benewah	Heyburn State Park
45.0	Bingham	Blackfoot River
46.0	Blaine	Sun Valley
46.1	Blaine	Alturas Lake
47.0	Boise	Lowman
48.0	Bonner	Lake Pend Oreille
48.1	Bonner	Priest Lake
49.0	Bonneville	Palisades Reservoir
50.0	Boundary	Copeland

(continued)

TABLE A.2 (continued)

Recreation Centroid Number	County	Recreation Centroid
51.0	Butte	Craters Moon
52.0	Camas	Magic Reservoir
53.0	Canyon	Lake Lowell
54.0	Caribou	Blackfoot Reservoir
55.0	Cassia	Lake Cleveland
55.1	Cassia	Snake River
56.0	Clark	Sheridan Reservoir
57.0	Clearwater	Dworshak Reservoir
58.0	Custer	Mackay Reservoir
58.1	Custer	Stanley Basin Recreation Area
59.0	Elmore	Anderson Ranch
59.1	Elmore	Atlanta
60.0	Franklin	Devil Creek Reservoir
61.0	Fremont	Island Park Reservoir
62.0	Gem	Black Canyon Dam
63.0	Gooding	Hagerman Valley
64.0	Idaho	Corn Creek
64.1	Idaho	Pittsburg Landing
64.2	Idaho	Selway Falls
64.3	Idaho	Powell Recreation Area
65.0	Jefferson	Snake River
66.0	Jerome	Snake River
67.0	Kootenai	Fernan Lake
68.0	Latah	Deary Helmer Area
69.0	Lemhi	Yellow J. Lake
70.0	Lewis	Winchester Lake
71.0	Lincoln	Richfield Area
72.0	Madison	Snake River
73.0	Minidoka	Snake River
74.0	Nez Perce	Hells Gate
75.0	Oneida	Daniels Reservoir
76.0	Owyhee	Mountain View Reservoir
76.1	Owyhee	Bruneau State Park
77.0	Payette	Payette
78.0	Power	American Falls Reservoir
79.0	Shoshone	St. Joe River
80.0	Teton	Victor Area
81.0	Twin Falls	Cedar Creek Reservoir
81.1	Twin Falls	Snake River
82.0	Valley	Dagger Falls
82.1	Valley	McCall Lake
83.0	Washington	Brownlee Reservoir
84.0	Baker	Phillips Reservoir
85.0	Benton	River Park
86.0	Clackamas	Milo McLeur State Park

(continued)

TABLE A.2 (continued)

Recreation Centroid Number	County	Recreation Centroid
86.1	Clackamas	Mount Hood Area
87.0	Clatsop	Ecola State Park
87.1	Clatsop	Fort Stevens State Park
88.0	Columbia	Scaponia
89.0	Coos	Sunset Bay State Park
90.0	Crook	Prineville Res. State Park
91.0	Curry	Boardman State Park
91.1	Curry	Humbug Mountain State Park
92.0	Deschutes	Wickiup Reservoir
92.1	Deschutes	Tumalo
93.0	Douglas	Winchester Bay
93.1	Douglas	Diamond Lake
93.2	Douglas	Wildlife Safari
93.3	Douglas	Sutherlin
94.0	Gilliam	J. S. Burres State Park
95.0	Grant	Clyde Holiday State Park
96.0	Harney	Malheur Lake
97.0	Hood River	Bonneville Dam
98.0	Jackson	Howard Prairie
98.1	Jackson	Lost Creek Area
99.0	Jefferson	Cove Palisades State Park
100.0	Josephine	Indian Mary C. Park
101.0	Klamath	Klamath Lake
101.1	Klamath	Crater Lake
102.0	Lake	Goose Lake
103.0	Lane	Honeymoon State Park
103.1	Lane	MacKenzie Bridge
103.2	Lane	Fern Ridge Reservoir
104.0	Lincoln	Otter Crest
104.1	Lincoln	Devils Lake State Park
105.0	Linn	Foster Lake
106.0	Malheur	Lake Owyhee State Park
107.0	Marion	Detroit Lake
108.0	Morrow	Boardman Park
109.0	Multnomah	Rooster Rock
110.0	Polk	Independence
111.0	Sherman	Deschutes River State Park
112.0	Tillamook	Tillamook Bay
113.0	Umatilla	Weston Area
114.0	Union	Hilgard Junction State Park
115.0	Wallowa	Wallowa Lake
116.0	Wasco	Memaloose State Park
117.0	Washington	Scoggins Reservoir
118.0	Wheeler	Shelton Wayside
119.0	Yamhill	Stewert Grenfeld State Park

(continued)

TABLE A.2 (continued)

Recreation Centroid Number	County	Recreation Centroid
120.0	Lake	Flathead Lake (1)
120.1	Lake	Flathead Lake (2)
121.0	Flathead	Flathead River (1)
121.1	Flathead	Flathead River (2)
121.2	Flathead	Hungry Horse Dam
121.3	Flathead	Whitefish Lake
121.4	Flathead	McGregor Lake
125.0	Lincoln	Lake Koocanusa
126.0	Missoula	Lake Alva
127.0	Canada[1]	Calgary Rec.[2]
127.1	Canada[1]	Cranbrook Rec.
126.1	Missoula	Missoula Rec.
129.0	Deer Lodge	Butte Rec.
130.0	Meagher	Helena Rec.
131.0	Cascade	Great Falls Rec.
132.0	Park	Bozeman Rec.

[1] These two recreation centroids are in Canada.

[2] The recreation centroids defined by Rec. reflect a proxy for the composite recreation sites close to a particular population center.

TABLE A.3

RECREATION ACTIVITY DAYS PRODUCED BY CENTROID

Recreation Centroid Number	Washington Activity Occasions (in 100)				
	County	Swimming	Camping	Fishing	Boating
1.0	Adams	987	1,128	671	661
2.0	Asotin	1,299	1,484	882	870
3.0	Benton	3,399	3,884	2,309	2,276
3.1	Benton	5,316	6,076	3,611	3,561
4.0	Chellan	3,710	4,240	2,521	2,485
5.0	Clallem	4,134	4,724	2,808	2,769
6.0	Clark	14,721	16,824	10,001	9,861
7.0	Columbia	341	389	231	228
8.0	Cowlitz	6,460	7,383	4,389	4,327
9.0	Douglas	1,666	447	266	262
10.0	Ferry	391	447	266	262
11.0	Franklin	2,678	3,061	1,819	1,794
12.0	Garfield	290	239	142	140
13.0	Grant	3,560	4,069	2,419	2,385
14.0	Grays Harbor	5,293	6,050	3,596	3,546
15.0	Island	3,247	3,711	2,206	2,175
16.0	Jefferson	1,266	1,447	860	848
17.0	King	95,739	109,415	65,042	64,129
17.1	King	4,352	4,973	2,956	2,915
17.2	King	3,264	3,730	2,217	2,186
17.3	King	4,352	4,973	2,956	2,915
17.4	King	1,088	1,243	739	729
18.0	Kitsap	11,242	12,848	7,637	7,530
19.0	Kittitas	1,816	2,075	1,233	1,216
20.0	Klickitat	1m204	1,376	818	807
21.0	Lewis	4,289	4,902	2,914	2,873
22.0	Lincoln	820	937	557	549
23.0	Mason	2,409	2,753	1,636	1,613
24.0	Okanogan	2,358	2,695	1,602	1,580
25.0	Pacific	1,413	1,615	960	947
26.0	Pend Oreille	593	678	493	397
27.0	Pierce	36,682	41,922	24,920	24,571
28.0	San Juan	658	752	447	441
29.0	Skagit	4,698	5,369	3,992	3,147
30.0	Skamania	554	633	376	371
31.0	Snohomish	17,027	19,459	11,567	11,412
31.1	Snohomish	8,771	10,025	9,959	5,879
32.0	Spokane	26,374	30,142	17,917	17,666
33.0	Stevens	2,079	2,376	1,412	1,393
34.0	Thurston	9,884	11,296	6,715	6,621
35.0	Wahkiakum	289	330	196	193
36.0	Walla Walla	3,524	4,028	2,394	2,361
37.0	Whatcom	8,205	9,377	5,574	5,496
38.0	Whitman	2,595	2,966	1,763	1,738
39.0	Yakima	13,006	14,864	8,836	8,712
	Total	327,962	374,812	222,801	219,691

(continued)

TABLE A.3 (continued)

Recreation Centroid Number	Idaho Activity Occasions (in 100)				
	County	Swimming	Camping	Fishing	Boating
40.0	Ada	4,143	11,287	9,972	3,172
41.0	Adams	73	199	176	56
42.0	Bannock	1,412	3,846	3,398	1,081
43.0	Bear Lake	141	383	339	108
44.0	Benewah	181	493	436	139
45.0	Bingham	714	1,944	1,717	546
46.0	Blaine	232	632	558	178
47.0	Boise	64	174	154	49
48.0	Bonner	500	1,363	1,204	383
49.0	Bonneville	1,434	3,907	3,452	1,098
50.0	Boundary	152	413	365	116
51.0	Butte	69	188	166	53
52.0	Camas	2	6	5	2
53.0	Canyon	1,771	4,824	4,262	1,356
54.0	Caribou	185	504	445	142
55.0	Cassia	423	1,151	1,017	323
56.0	Clark	19	52	46	15
57.0	Clearwater	225	614	543	173
58.0	Custer	72	19	173	55
59.0	Elmore	417	1,136	1,003	319
60.0	Franklin	169	460	406	129
61.0	Fremont	206	561	496	158
62.0	Gem	247	673	594	189
63.0	Gooding	239	652	576	183
64.0	Idaho	313	852	753	239
65.0	Jefferson	287	782	691	220
66.0	Jerome	311	846	747	238
67.0	Kootenai	1,313	3,576	3,159	1,006
68.0	Latah	571	1,555	1,374	437
69.0	Lemhi	162	440	489	124
70.0	Lewis	91	247	218	69
71.0	Lincoln	73	199	176	56
72.0	Madison	330	900	795	253
73.0	Minidoka	391	1,066	942	300
74.0	Nez Perce	793	2,160	1,908	607
75.0	Oneida	66	180	159	51
76.0	Owyhee	147	400	354	112
77.0	Payette	336	915	809	257
78.0	Power	144	393	347	110
79.0	Shoshone	436	1,187	1,048	333
80.0	Teton	58	157	139	44
81.0	Twin Falls	1,194	3,253	2,874	914
82.0	Valley	130	353	312	99
83.0	Washington	186	508	449	143
	Total	20,422	55,627	49,146	15,634

(continued)

TABLE A.3 (continued)

Recreation Centroid Number	Oregon Activity Occasions (in 100)				
	County	Swimming	Camping	Fishing	Boating
84.0	Baker	466	948	554	294
85.0	Benton	1,779	3,618	2,115	1,122
86.0	Clackamas	181	12,571	7,351	3,900
86.1	Clackamas	1,450	2,949	1,724	915
87.0	Clatsop	983	2,000	1,169	620
88.0	Columbia	1,097	2,232	1,305	692
89.0	Coos	482	981	574	304
89.1	Coos	1,447	2,943	1,721	913
90.0	Crook	395	804	470	249
91.0	Curry	398	810	474	251
91.1	Curry	112	229	134	71
92.0	Deschutes	1,918	3,991	2,281	1,210
93.0	Douglas	2,741	5,575	3,260	1,730
94.0	Gilliam	60	122	71	38
95.0	Grant	243	494	289	153
96.0	Harney	253	515	301	160
97.0	Hood River	498	1,012	592	314
98.0	Jackson	3,371	6,857	4,010	2,128
98.1	Jackson	460	935	547	290
99.0	Jefferson	323	547	384	204
100.0	Josephine	1,651	3,359	1,964	1,042
101.0	Klamath	1,724	3,507	2,050	1,088
102.0	Lake	222	451	264	140
103.0	Lane	8,229	16,738	9,787	5,193
104.0	Lincoln	618	1,257	735	390
104.1	Lincoln	466	948	554	294
105.0	Linn	2,605	5,299	3,098	1,644
106.0	Malheur	494	1,005	588	312
106.1	Malheur	243	495	289	154
107.0	Marion	5,428	11,040	6,455	3,425
107.1	Marion	671	1,365	798	423
108.0	Morrow	259	527	308	163
109.0	Multnomah	19,768	40,207	23,510	12,475
110.0	Polk	1,283	2,609	1,526	809
111.0	Sherman	68	139	81	43
112.0	Tillamook	668	1,359	794	422
113.0	Umatilla	1,703	3,465	2,026	1,075
114.0	Union	681	1,384	809	430
115.0	Wallowa	216	440	257	136
116.0	Wasco	696	1,416	828	439
117.0	Washington	8,175	16,628	9,723	5,159
118.0	Wheeler	47	96	56	30
119.0	Yamhill	1,653	3,361	1,966	1,043
	Total	82,228	167,248	97,792	51,887

(continued)

TABLE A.3 (continued)

Recreation Centroid Number	Western Montana Activity Occasions (in 100)				
	County	Swimming	Camping	Fishing	Boating
120.0	Cascade	3,591	4,948	3,798	2,439
121.0	Flathead	2,317	3,192	2,450	1,574
122.0	Gallatin	1,729	2,382	1,829	1,175
123.0	Jefferson	261	359	276	177
124.0	Lake	761	1,047	804	516
125.0	Lewis and Clark	2,020	2,780	2,130	1,370
126.0	Lincoln	731	1,008	774	497
127.0	Missoula	3,702	5,101	3,916	2,515
128.0	Silver Bow	3,876	5,341	4,100	2,633
	Total	17,181	23,656	18,160	11,663
	External Zones				
129.0	Eastern Montana	4,400	5,200	4,500	2,700
130.0	Vancouver, B.C.	2,481	1,684	1,172	3,432
131.0	Cranbrook, B.C.	275	187	130	381
132.0	Calgary	1,300	900	650	1,906
133.0	Wyoming	120	198	68	96
134.0	Utah	2,106	3,465	1,183	1,699
135.0	Nevada	220	479	164	236
136.0	California	15,603	24,736	8,436	12,156
137.0	Alaska	64	105	36	52
138.0	Eastern Canada	1,456	971	652	1,906
139.0	North Central	1,298	2,137	729	1,045
140.0	Northeast	595	980	335	479
141.0	Southeast	323	531	181	260
142.0	South Central	1,132	1,864	637	914

Note: Missoula county includes Mineral and Granite counties. Silver Bow county includes: Deer Lodge, Powell, Beaverhead, and Ravalli counties.

TABLE A.4

RECREATION FACILITY VARIABLES, EXISTING AND POTENTIAL, FROM IMPROVED WATER QUALITY BY RECREATION CENTROID

Recreation Centroid Number	County	Campsites		Linear Beach Feet		Boat Ramps		River Miles	
		Exist.	Pot.	Exist.	Pot.	Exist.	Pot.	Exist.	Pot.
1.0	Adams	0	0	0	0	3	3	381	381
2.0	Asotin	0	35	2000	2231	7	10	148	198
3.0	Benton	108	108	1850	2850	17	17	300	503
4.0	Chelan	340	340	200	200	4	4	362	370
4.1	Chelan	359	359	870	870	4	4	362	370
5.0	Clallum	92	102	1200	1200	4	4	200	200
5.1	Clallum	125	125	1100	1100	5	5	56	87
5.2	Clallum	75	75	1100	1100	4	4	250	250
6.0	Clark	147	147	1085	1085	14	14	291	291
7.0	Columbia	40	40	0	0	3	4	241	365
8.0	Cowlitz	75	75	0	0	14	14	250	250
8.1	Cowlitz	138	138	0	0	4	4	140	140
9.0	Douglas	33	130	100	294	3	4	314	452
10.0	Ferry	117	167	400	400	4	4	525	745
11.0	Franklin	67	67	1000	1000	9	9	246	246
12.0	Garfield	0	0	0	0	0	0	210	215
13.0	Grant	263	292	1000	1140	15	16	308	350
13.1	Grant	296	425	2930	3124	2	1	58	100
13.2	Grant	173	173	1000	1000	5	5	276	276
14.0	Grays Harbor	191	191	0	0	8	8	150	150
14.1	Grays Harbor	177	177	450	723	10	12	235	300
14.2	Grays Harbor	100	113	270	358	8	9	244	263
15.0	Island	348	348	0	0	10	10	0	0
15.1	Island	254	254	600	600	14	14	0	0
16.0	Jefferson	125	155	2360	2658	8	8	122	180
16.1	Jefferson	125	125	2000	2000	2	2	281	281
16.2	Jefferson	150	150	3350	3350	6	6	450	450
17.0	King	138	179	1925	2198	11	13	483	542
17.1	King	150	241	3000	3601	12	16	220	350
17.2	King	0	0	7000	7000	39	39	100	100
18.0	Kitsap	198	198	1400	1400	16	16	41	41
19.0	Kittitas	25	66	7000	7000	4	4	142	200
19.1	Kittitas	415	415	4500	4500	9	9	489	489
20.0	Klickitat	104	104	1325	1325	12	12	622	706
21.0	Lewis	350	350	1995	2383	14	16	514	598
22.0	Lincoln	80	80	1300	1300	2	2	198	198
22.1	Lincoln	80	80	1300	1300	1	1	180	180
22.2	Lincoln	67	67	1400	1400	1	1	220	220
23.0	Mason	140	140	240	240	5	5	120	120
23.1	Mason	250	250	400	400	5	5	120	120
23.2	Mason	156	156	240	240	5	5	110	110

(continued)

TABLE A.4 (continued)

Recreation Centroid Number	County	Campsites		Linear Beach Feet		Boat Ramps		River Miles	
		Exist.	Pot.	Exist.	Pot.	Exist.	Pot.	Exist.	Pot.
24.0	Okanogan	120	120	275	275	4	4	800	800
24.1	Okanogan	120	170	1100	1588	4	7	241	347
24.2	Okanogan	300	350	500	592	4	4	80	100
24.3	Okanogan	168	179	867	1028	4	5	265	300
25.0	Pacific	300	300	0	0	12	12	281	290
26.0	Pend Oreille	610	616	1450	1491	5	5	241	250
26.1	Pend Oreille	100	100	400	400	2	2	40	40
27.0	Pierce	40	40	900	900	6	6	100	100
27.1	Pierce	186	200	900	992	5	6	178	198
27.2	Pierce	40	92	1800	2145	6	8	45	120
28.0	San Juan	675	675	1030	1030	7	7	7	7
29.0	Skagit	254	254	300	300	10	10	260	260
29.1	Skagit	240	248	0	69	9	9	285	300
30.0	Skamania	152	152	500	500	3	3	275	275
31.0	Snohomish	137	137	1600	1674	9	9	334	360
31.1	Snohomish	140	140	1715	1715	7	7	340	340
32.0	Spokane	4	4	150	150	5	5	61	61
32.1	Spokane	4	26	40	40	1	2	94	125
32.2	Spokane	25	25	100	100	1	1	50	50
32.3	Spokane	4	4	0	0	3	3	75	75
32.4	Spokane	117	139	40	1040	1	2	119	150
33.0	Stevens	70	70	300	300	4	4	219	319
33.1	Stevens	70	70	300	300	4	4	250	400
33.2	Stevens	78	78	300	300	3	3	100	100
34.0	Thurston	248	248	849	1349	4	12	174	235
35.0	Wahkiakum	0	0	0	0	0	0	114	114
36.0	Walla Walla	189	189	700	700	8	8	263	360
37.0	Whatcom	179	179	800	800	7	7	40	40
37.1	Whatcom	150	150	1000	1000	6	6	413	413
37.2	Whatcom	101	101	750	750	18	18	180	180
37.3	Whatcom	125	125	1150	1150	11	11	60	60
38.0	Whitman	99	104	800	832	10	10	639	646
39.0	Yakima	592	811	5200	6640	2	11	728	1041
40.0	Ada	290	290	1960	1960	4	4	79	79
41.0	Adams	198	198	400	450	5	6	345	373
42.0	Bannock	663	663	0	300	1	1	266	290
43.0	Bear Lake	297	297	300	350	3	4	241	283
44.0	Benewah	167	167	1100	1100	15	15	159	159
45.0	Bingham	276	276	650	750	8	11	130	240
46.0	Blaine	275	275	33	85	13	14	0	104
46.1	Blaine	413	413	32	32	8	8	407	407
47.0	Boise	434	434	250	250	3	3	504	509
48.0	Bonner	675	675	3830	3830	16	16	152	152
48.1	Bonner	1265	1365	6750	6800	26	28	310	325

(continued)

TABLE A.4 (continued)

Recreation Centroid Number	County	Campsites		Linear Beach Feet		Boat Ramps		River Miles	
		Exist.	Pot.	Exist.	Pot.	Exist.	Pot.	Exist.	Pot.
49.0	Bonneville	472	472	100	200	60	62	177	275
50.0	Boundary	221	221	525	525	8	8	457	457
51.0	Butte	83	83	0	50	0	1	66	170
52.0	Camas	93	93	50	50	1	1	408	437
53.0	Canyon	40	40	150	300	4	8	65	90
54.0	Caribou	131	131	0	50	10	11	533	594
55.0	Cassia	400	400	0	25	1	2	316	389
55.1	Cassia	0	0	0	25	7	8	140	200
56.0	Clark	41	41	0	50	0	1	153	200
57.0	Clearwater	323	423	155	305	9	12	534	577
58.0	Custer	112	162	431	831	1	5	76	425
58.1	Custer	1013	1013	2444	2444	4	4	0	50
59.0	Elmore	182	182	2340	2340	7	7	288	300
59.1	Elmore	180	180	260	260	1	1	311	311
60.0	Franklin	340	365	100	150	5	7	114	149
61.0	Fremont	458	458	0	100	8	10	238	353
62.0	Gem	47	47	725	725	5	5	76	76
63.0	Gooding	324	324	0	200	3	4	111	116
64.0	Idaho	15	40	250	300	1	1	470	552
64.1	Idaho	200	200	500	500	0	0	550	550
64.2	Idaho	200	200	25	25	0	0	555	555
64.3	Idaho	80	80	100	100	0	0	545	545
65.0	Jefferson	22	22	100	200	0	1	16	71
66.0	Jerome	95	95	0	0	1	1	43	43
67.0	Kootenai	1123	1123	5500	5700	82	85	236	262
68.0	Latah	65	65	50	50	1	1	292	292
69.0	Lehmi	474	524	200	400	5	9	1003	1053
70.0	Lewis	34	34	0	0	3	3	150	150
71.0	Lincoln	6	6	0	0	0	1	31	91
72.0	Madison	28	28	50	100	0	1	30	58
73.0	Minidoka	102	102	1465	1465	4	4	31	31
74.0	Nez Perce	302	302	1200	1200	10	10	243	243
75.0	Oneida	36	36	0	50	2	3	58	90
76.0	Owyhee	128	128	1100	1150	4	5	174	574
76.1	Owyhee	85	85	0	0	6	6	149	174
77.0	Payette	0	0	0	0	0	0	78	78
78.0	Power	112	112	0	0	10	11	104	124
79.0	Shoshone	237	237	0	300	0	2	682	716
80.0	Teton	78	78	0	100	1	2	51	82
81.0	Twin Falls	16	16	0	25	4	5	107	167
81.1	Twin Falls	147	147	0	25	5	6	83	150
82.0	Valley	623	623	9000	9000	12	12	374	374
82.1	Valley	267	267	3350	3650	5	9	320	375
83.0	Washington	128	128	150	150	0	1	179	219

(continued)

TABLE A.4 (continued)

Recreation Centroid Number	County	Campsites		Linear Beach Feet		Boat Ramps		River Miles	
		Exist.	Pot.	Exist.	Pot.	Exist.	Pot.	Exist.	Pot.
84.0	Baker	488	488	8300	8300	14	14	827	827
85.0	Benton	37	37	0	940	2	2	155	249
86.0	Clackamas	755	830	900	1300	3	4	375	425
86.1	Clackamas	495	495	1000	1000	3	3	295	295
87.0	Clatsop	520	520	11415	11415	9	9	165	165
87.1	Clatsop	520	520	11415	11415	9	9	169	169
88.0	Columbia	71	71	0	0	1	1	308	308
89.0	Coos	1525	1625	2000	2075	23	25	131	507
90.0	Crook	221	421	300	450	3	5	552	642
91.0	Curry	1236	1236	7750	7750	13	13	200	200
91.1	Curry	281	281	3000	3000	1	1	206	206
92.0	Deschutes	750	750	40	40	6	6	169	169
92.1	Deschutes	776	916	35	435	6	7	85	140
93.0	Douglas	500	584	1300	2100	13	16	150	175
93.1	Douglas	500	585	1300	2100	13	15	670	700
93.2	Douglas	674	874	1450	2210	12	15	25	156
93.3	Douglas	500	700	1300	2100	13	15	70	200
94.0	Gilliam	20	20	0	0	3	3	382	382
95.0	Grant	273	273	0	0	12	12	1077	1120
96.0	Harney	321	371	0	0	8	8	804	1238
97.0	Hood River	427	447	1280	1280	7	7	116	194
98.0	Jackson	650	650	700	700	20	20	375	375
98.1	Jackson	693	693	700	700	19	19	400	400
99.0	Jefferson	1750	1790	4900	5200	31	32	409	432
100.0	Josephine	1087	1087	0	0	30	30	451	451
101.0	Klamath	630	730	7080	7800	22	25	340	340
101.1	Klamath	633	633	7083	7083	22	22	264	336
102.0	Lake	324	324	0	0	11	11	355	389
103.0	Lane	658	788	5000	5400	33	36	170	22
103.1	Lane	1200	1330	5000	5400	33	36	673	700
103.2	Lane	200	348	6608	6938	33	35	75	225
104.0	Lincoln	800	920	150	150	7	7	127	222
104.1	Lincoln	538	568	50	50	20	20	50	100
105.0	Linn	861	886	4300	5530	26	29	624	747
106.0	Malheur	273	273	4725	4725	7	7	1897	1935
107.0	Marion	1628	1628	7510	7510	14	14	460	493
108.0	Morrow	156	156	0	0	2	2	460	493
109.0	Multnomah	184	184	10218	10218	21	23	130	147
110.0	Polk	16	16	1350	2140	11	14	172	251
111.0	Sherman	132	132	0	0	4	4	282	282
112.0	Tillamook	1100	1100	18000	18000	18	18	175	175
112.1	Tillamook	1088	1088	18960	18960	18	18	174	177
113.0	Umatilla	273	273	1300	1300	14	14	752	842
114.0	Union	183	183	10	10	3	4	524	535

(continued)

TABLE A.4 (continued)

Recreation Centroid Number	County	Campsites		Linear Beach Feet		Boat Ramps		River Miles	
		Exist.	Pot.	Exist.	Pot.	Exist.	Pot.	Exist.	Pot.
115.0	Wallowa	522	522	400	400	4	4	998	998
116.0	Wasco	590	590	2000	2000	8	8	805	805
117.0	Washington	67	77	1200	1720	2	4	204	256
118.0	Wheeler	80	80	0	0	0	0	375	375
119.0	Yamhill	52	127	0	500	0	2	198	290

	County	Campsites	Beach Feet	Boat Ramps	River Miles
120.0	Lake	48	1100	7	55
120.1	Lake	96	1100	8	55
121.0	Flathead	1	1	4	96
121.1	Flathead	1	1	3	58
121.2	Flathead	175	100	7	72
121.3	Flathead	10	600	4	16
121.4	Flathead	20	300	4	120
125.0	Lincoln	30	900	3	50
126.0	Missoula	40	300	3	50
127.0	Canada[1]	500	350	4	100
128.0	Canada[1]	500	3300	4	100
126.1	Missoula	480	350	13	70
129.0	Bear Lodge	876	4200	19	50
130.0	Meagher	482	4500	9	64
131.0	Cascade	159	900	4	40
132.0	Park	750	900	14	120

Notes: Exist. means currently existing. Pot. means potential; that is, the potential facilities (or river miles) that could be constructed if all degraded rivers were improved so as to be acceptable for recreation purposes.

[1] These recreation centroids are near Calgary and Cranbrook, respectively.

TABLE A.5

ANNUAL (1980) RECREATION VALUE BY ACTIVITY AND BY COUNTY FOR WASHINGTON, IDAHO, AND OREGON

Zone Number	County Name	Recreation Value, Washington (in dollars)				
		Swimming	Camping	Fishing	Boating	Total
1	Adams	$418,732	$124,046	$825,649	$674,596	$2,043,023
2	Asotin	317,286	267,561	310,729	204,062	1,099,638
3	Benton	694,835	744,426	496,187	564,788	2,500,236
4	Chelan	2,215,635	4,477,158	1,539,314	1,609,433	9,841,540
6	Clallum	2,792,041	2,105,443	1,457,025	1,637,269	7,991,778
9	Clark	5,219,251	4,166,888	2,644,397	6,081,738	18,112,274
10	Columbia	189,053	436,056	489,887	242,627	1,357,623
11	Cowlitz	2,057,886	5,256,482	3,308,244	5,319,961	15,942,573
13	Douglas	520,114	859,498	484,039	221,079	2,084,730
14	Ferry	572,054	1,043,430	542,865	322,250	2,480,599
15	Franklin	606,553	582,571	500,445	439,460	2,129,029
16	Garfield	143,368	59,728	409,595	81,671	696,362
17	Grant	2,010,921	3,740,331	1,312,042	1,122,036	8,185,330
20	Grays Harbor	2,601,004	5,089,433	2,211,118	4,254,056	14,155,611
23	Island	5,103,889	9,601,347	2,400,678	13,171,954	30,277,868
25	Jefferson	4,309,672	3,615,155	1,996,718	2,964,559	12,885,104
29	King	49,635,416	16,920,861	14,558,351	115,215,125	195,219,753
31	Kitsap	2,808,435	2,637,427	1,087,164	3,859,918	10,392,944
32	Kittitas	6,747,085	6,415,688	2,571,265	5,671,063	21,415,101
34	Klickitat	1,334,830	1,305,933	1,020,827	1,020,862	4,682,452
35	Lewis	4.582,449	5,351,179	2,044,047	6,991,453	18,969,128
36	Lincoln	3,458,897	2,903,928	2,054,917	906,117	9,323,859
39	Mason	14,629,231	13,323,855	6,965,910	18,191,191	53,110,187
42	Okanogan	4,482,324	5,776,672	2,846,955	1,566,587	14,672,538
46	Pacific	359,415	2,190,611	744,379	1,141,501	4,425,906
47	Pend Oreille	1,237,846	2,958,325	925,770	639,492	5,761,433
49	Pierce	18,545,658	9,979,171	1,904,041	22,029,498	57,458,368
52	San Juan	1,404,485	3,119,350	532,618	1,127,575	6,184,028
53	Skagit	4,982,385	6,578,156	2,953,124	7,846,645	22,360,310
55	Skamania	4,175,050	4,068,523	2,883,744	2,242,283	13,369,600
57	Snohomish	16,375,406	9,365,677	5,086,977	19,330,802	50,878,862
59	Spokane	13,261,349	6,895,249	8,856,214	10,521,165	39,533,977
64	Stevens	3,995,138	3,900,172	2,976,602	2,991,068	13,862,980
67	Thurston	7,317,709	6,468,939	2,872,549	11,579,364	28,238,561
68	Wahkiakum	968,438	231,069	1,598,016	1,596,378	4,393,901
69	Walla Walla	1,107,209	1,368,908	765,048	763,027	4,004,192
70	Whatcom	3,660,551	4,476,638	2,014,450	3,589,988	13,741,627
74	Whitman	1,506,345	1,542,352	1,111,546	1,724,077	7,884,320
75	Yakima	1,784,770	3,972,679	838,726	1,605,125	8,201,300
	State Total	$198,134,715	$163,910,915	$94,762,172	$281,060,843	$737,868,645

(continued)

TABLE A.5 (continued)

Zone Number	County Name	Recreation Value, Idaho (in dollars)				
		Swimming	Camping	Fishing	Boating	Total
76	Ada	$643,736	$1,348,072	$1,279,777	$92,765	$3,354,350
77	Adams	40,860	200,200	150,935	12,723	404,718
78	Bannock	223,012	1,354,811	1,153,465	11,566	2,742,854
79	Bear Lake	95,777	544,829	603,709	8,307	1,252,622
80	Benewah	1,041,242	1,664,328	753,164	1,533,043	5,001,777
81	Bingham	221,638	727,532	1,025,614	46,766	2,021,550
82	Blaine	55,173	537,698	337,267	22,141	952,279
84	Boise	73,166	488,164	321,526	13,290	896,146
85	Bonner	2,211,064	6,151,289	1,274,625	2,691,692	12,328,670
87	Bonneville	102,547	664,612	688,426	77,149	1,532,734
88	Boundary	376,725	983,203	430,045	317,660	2,107,633
89	Butte	42,735	254,790	493,668	6,725	797,918
90	Camas	71,696	275,700	461,566	5,968	814,930
91	Canyon	386,587	472,809	1,106,917	83,869	2,050,182
92	Caribou	26,197	238,547	440,539	11,235	716,518
93	Cassia	224,741	1,392,720	2,424,434	87,126	4,230,132
95	Clark	27,653	136,727	378,111	4,247	546,738
96	Clearwater	167,255	709,087	304,967	143,045	1,324,354
97	Custer	103,848	606,000	388,627	9,302	1,107,777
99	Elmore	317,244	893,402	1,045,508	45,242	2,301,396
101	Franklin	102,925	621,482	663,081	15,229	1,402,617
102	Fremont	20,087	347,379	308,287	8,602	684,355
103	Gem	334,305	384,406	817,416	70,295	1,606,422
104	Gooding	101,542	1,057,230	951,653	36,584	2,147,009
105	Idaho	277,789	824,850	685,628	53,443	1,952,710
109	Jefferson	300,407	298,537	1,326,688	21,989	1,987,621
110	Jerome	112,146	610,502	979,517	19,771	1,721,936
111	Kootenai	4,660,328	9,306,606	1,929,019	18,634,145	34,530,098
112	Latah	117,772	326,918	230,153	40,118	714,961
113	Lemhi	8,218	107,438	74,139	1,835	191,630
114	Lewis	89,253	291,485	325,064	99,814	805,616
115	Lincoln	51,082	88,233	494,576	8,907	640,798
116	Madison	251,059	324,523	1,359,088	20,510	1,955,180
117	Minidoka	422,061	701,064	1,174,084	51,953	2,349,162
118	Nez Perce	546,957	1,288,813	537,271	424,070	2,797,111
119	Oneida	78,552	321,227	959,115	14,031	1,372,925
120	Owyhee	104,255	558,574	844,756	43,942	1,551,527
122	Payette	108,783	52,761	758,055	23,963	943,562
123	Power	148,075	715,241	1,599,766	90,236	2,553,329
124	Shoshone	129,753	1,123,893	409,826	102,220	1,765,692
125	Teton	39,476	225,307	517,499	4,708	786,990
126	Twin Falls	138,367	806,319	1,410,276	61,442	2,416,404
128	Valley	168,998	686,855	399,642	44,877	1,300,372
130	Washington	129,365	389,560	455,427	13,925	988,277
	State Total	$14,849,336	$41,447,118	$34,386,352	$25,225,203	$115,908,009

(continued)

TABLE A.5 (continued)

Zone Number	County Name	Recreation Value, Oregon (in dollars)				
		Swimming	Camping	Fishing	Boating	Total
131	Baker	$141,457	$561,255	$200,539	$63,442	$966,693
132	Benton	827,292	1,252,484	1,667,586	5,599,918	4,307,280
133	Clackamas	4,772,207	10,898,672	3,131,003	1,663,320	20,465,202
135	Clatsop	3,353,411	5,539,193	1,553,691	1,401,502	11,847,797
137	Columbia	912,365	1,957,309	1,685,883	570,635	5,126,192
138	Coos	175,528	993,108	197,613	79,706	1,445,955
139	Crook	110,386	536,669	216,667	43,073	906,795
140	Curry	172,808	539,296	211,894	14,001	937,999
142	Deschutes	480,344	3,634,461	804,946	324,188	5,243,939
144	Douglas	1,846,194	5,250,715	1,662,190	805,572	9,564,671
148	Gilliam	164,645	333,351	451,784	175,736	1,125,516
149	Grant	35,176	503,063	205,665	78,217	822,121
150	Harney	9,036	194,990	81,409	8,944	294,379
151	Hood River	3,107,820	5,045,580	1,541,053	1,836,999	11,641,452
152	Jackson	598,764	2,021,986	731,808	223,571	3,576,129
154	Jefferson	521,123	3,194,512	438,121	552,449	4,706,205
155	Josephine	95,934	1,148,556	345,897	140,261	1,740,648
156	Klamath	611,989	1,782,220	568,538	213,087	3,175,834
158	Lake	82,309	909,666	352,077	114,146	1,458,198
159	Lane	3,471,636	7,317,266	2,249,034	2,723,584	14,761,480
162	Lincoln	1,411,179	6,308,622	1,683,258	1,607,926	11,110,985
164	Linn	1,851,516	4,341,859	1,218,805	1,492,862	8,905,042
165	Malheur	166,984	355,532	473,956	26,483	1,134,066
166	Marion	1,493,100	5,265,461	1,001,303	817,479	8,677,343
167	Morrow	130,070	808,591	427,914	110,449	1,481,024
168	Multnomah	8,050,763	4,697,102	2,784,334	7,293,007	22,825,206
169	Polk	3,316,113	906,166	1,890,496	2,241,450	8,374,225
170	Sherman	350,726	1,342,707	802,698	444,574	2,940,705
171	Tillamook	4,017,140	8,290,208	1,809,872	2,105,897	16,223,117
173	Umatilla	365,126	828,568	373,757	279,471	1,846,922
174	Union	101,271	540,853	293,411	74,768	1,010,303
175	Wallowa	50,938	384,261	114,082	21,527	570,808
176	Wasco	1,634,881	3,517,436	1,166,457	857,965	7,176,739
177	Washington	3,145,591	2,003,162	1,726,816	1,160,209	8,036,778
178	Wheeler	53,209	341,281	221,735	28,802	645,027
179	Yamhill	2,176,145	2,255,131	1,602,844	588,034	6,622,254
State Total		$51,438,145	$95,891,547	$36,093,970	$30,592,428	$214,016,090
Region Total		$265,008,995	$300,057,296	$165,669,098	$336,035,293	$1,066,770,682

APPENDIX B

HOUSEHOLD SURVEY QUESTIONNAIRE

This appendix contains the questionnaire used by the Survey Research Center at Oregon State. The telephone survey included 3,000 households and was conducted in the Fall of 1980. Columns 1-4 on the code sheets are household identification numbers; columns 5-8 are card numbers; and column 9 is a state verification number. The responses to question one were coded in columns 10-11.

OREGON OUTDOOR RECREATION SURVEY

1.	10-11 Number 99 DK, NA		During the past 12 months, how many persons, including yourself, have lived in your household?
2.	12-13 Number 99 DK, NA		How many of these people are 18 years or older?
2a.	14-15 Number 99 DK, NA		And, how many are under 18 years of age? (INT: RESPONSE TO Q. 2 AND 2a MUST EQUAL TOTAL IN Q. 1)

3. I'd like to complete picture of your household. Some of these questions concern each person, while others are about your household as a group. Thinking about everyone who lived in your household during the past 12 months, I would like to list each person from the oldest to the youngest just to make sure we are talking about everyone. (INT: STARTING WITH THE OLDEST, GET ALL INFORMATION AND ENTER ON FIRST LINE. CONTINUE WITH EACH FAMILY MEMBER DOWN TO THE YOUNGEST.)

	Relationship to "R"	First Name	Sex (Circle) Male	Sex (Circle) Female	Age Last Birthday
Person 1		16	1	2	17-18
Person 2		19	1	2	20-21
Person 3		22	1	2	23-24
Person 4		25	1	2	26-27
Person 5		28	1	2	29-30

Person 6		31	1	2	32-33
Person 7		34	1	2	35-36
Person 8		37	1	2	38-39
Person 9		40	1	2	41-42
Person 10		43	1	2	44-45
Person 11		46	1	2	47-48
Person 12			1	2	

Now I'd like to ask you some questions about your household's outdoor recreation activities for the past 12 months.

4. Thinking back to the first of June 1980 to the present, how many trips, all together, did you or any member of your household take for these four kinds of outdoor recreation: swimming in a lake or river, boating, fishing, or camping?

49-51 Number of trips 99 DK, NA

(INT: IF "NONE," WRITE 0 AND SKIP TO Q. 7)

The next series of questions refers only to the last trip you or someone in your household took.

5.	$ 52-56 /day 99 DK (SKIP TO Q. 6)	First, how much was the daily use fee, if any, for the recreation facilities used? (INT: IF NONE, WRITE 0 AND SKIP TO Q. 6)
5a.	$ 57-61 /day 99 DK	What is the maximum daily use fee you would be willing to pay for this recreation facility rather than forego using it?
6.	$ 52-56 999 DK	About how much money did you spend travelling to and from your home to the recreation area on this last trip? This includes meals, gas, oil, car rental or air fare, and so forth. (Just your best estimate please.)
6a.	1 Enjoyed travel time 2 Prefer to shorten 66 9 DK	Some people feel time spent travelling to a recreation site is an inconvenience, while others enjoy it. How about you? Did you enjoy the time spent travelling on this trip, or would you rather have shortened the travel time?

6b.	$ 67-70	About how much money would you be willing to pay to shorten the total travel time for this last trip by half?

(ASK OF EVERYONE)

7.	71-73 Number of trips 99 DK	Now, thinking back to the first of September of last year to the first of June 1980, how many trips, all together, did you or any member of your houehold take for recreation purposes? (INT: IF NONE, WRITE 0 AND SKIP TO Q. 8)

Finally, for statistical purposes only, we have a few last questions about your household.

8.	Town or City 999 Refused	First, in or near which town or city is your home located?
9.	70-76 County 99 Refused; DK	And, in which county is your home located?
10.	01 Less than $10,000 02 $10,000 to $14,999 03 $14,000 to $19,999 04 $20,000 to $24,999 05 $25,000 to $34,999 06 $35,000 to $40,000 07 over $40,000 99 Refused; DK	Would you please tell me if the total gross income for your household in 1979 was ... (READ LIST)

11. Is there anything else you would like to say about outdoor recreation?

(THANK YOU FOR YOUR COOPERATION)

TABLE B.1

FREQUENCY DISTRIBUTION OF RECREATION TRIPS USING 1980 HOUSEHOLD SURVEY DATA

Oregon

Days	Number of Trips	Number of Days	Swimming	Boating	Fishing	Camping
- 1	273	273	414	143	182	10
2	130	260	133	98	320	485
>2	100	694	283	283	484	1194
Total	403	1227	830	524	986	1689
Proportion			0.206	0.130	0.245	0.419

Idaho

Days	Number of Trips	Number of Days	Swimming	Boating	Fishing	Camping
1	262	262	218	111	576	4
2	89	178	48	44	247	350
>2	144	646	338	305	630	1290
Total	495	1086	604	460	1453	1644
Proportion			0.415	0.111	0.349	0.395

Washington

Days	Number of Trips	Number of Days	Swimming	Boating	Fishing	Camping
1	479	479	748	470	398	12
2	113	226	250	211	337	502
>2	177	1181	1278	982	952	1528
Total	769	1886	2476	1663	1687	2042
Proportion			0.315	0.211	0.214	0.260

Note: The above estimates are based on a subsample of 313 households (123 from Washington, 100 from Oregon, and 90 from Idaho), but a total of 1767 recreation trips.

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